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Assessment of the Nain stock unit Arctic charr population in 1991

by

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Abstract

Reported landings of Arctic charr from the Nain assessment unit totaled 16 t in 1991, a decrease of 65% from the previous year. This was the lowest catch on record. Landings were only 34% of the 47 t TAC which has been in effect since 1987. Landings had been moderately stable from the mid-1980's until 1991. Severe ice conditions along the northern Labrador coast contributed to the disruption of normal fishing activities. Mean timing of the 1991 commercial charr fishery for the total Nain stock unit was 22 days later than the average during the past 14 years. Catch rates and effort declined in both inshore and offshore fishing zones with the total unit experiencing the lowest values since 1977. Catch at age data from the 1991 fishery indicated that the 1981 and 1982 year classes were the most abundant in the fishery contributing 48% of the catch. Standardized catch rates, estimated separately for both inshore and offshore fishing zones, were derived using a multiplicative model and used in an age disaggregated formulation of ADAPT to estimate fishing mortality and stock size in 1991. The assessment indicated that fishing mortality on age 10+ fish in 1991 was about 0.22 with an estimated population size of about 179,000 fish. Population size has remained relatively stable during the past ten years.

Résumé

Les débarquements déclarés d'omble chevalier provenant de l'unité d'évaluation de Nain ont atteint 16 t en 1991, soit 65 % de moins qu'en 1989. Il s'agissait des plus basses prises jamais connues. Ces débarquements ne représentaient que 34 % du TPA de 47 t, en vigueur depuis 1987. Ils sont demeurés assez stables depuis le milieu des années 1980. L'abondance de la glace le long du nord du Labrador a nui aux activités de pêche normales. En moyenne, la pêche commerciale de l'omble chevalier dans l'unité de Nain a commencé 22 jours plus tard que la moyenne des 14 dernières années. Les taux de prises et l'effort ont diminué dans les zones de pêche, tant côtière qu'hauturière, pour atteindre dans l'ensemble leur plus bas niveau depuis 1977. Les données sur les prises selon l'âge en 1991 révèlent que les classes d'âge de 1981 et 1982 étaient les plus abondantes dans la pêche, représentant 48 % des prises. On a eu recours à un modèle multiplicatif pour établir des taux de prises normalisés et distincts pour la pêche côtière et pour la pêche hauturière, puis on a appliqué ces taux de prises à une formulation de la méthode ADAPT décomposée par âge afin d'estimer la mortalité due à la pêche et la grosseur des stocks en 1991. Selon cette estimation, la mortalité due à la pêche dans les stocks de poissons de 10 ans et plus était d'environ 0,22 et la population se chiffrait approximativement à 179 000 poissons. La population est demeurée relativement stable durant les dix dernières années.

1. Introduction

The Nain stock unit (Fig. 1) consists of an inshore zone made up of Anaktalik Bay, Nain Bay, Tikkoatokak Bay, and Webb Bay subareas, and an offshore island zone consisting of the Dog Island and Black Island subareas (Dempson and Kristofferson 1987). It was first assessed as a single unit in 1985 (Dempson and LeDrew 1986). Prior to this, individual assessments were conducted separately on Arctic charr populations from Nain-Tikkoatokak Bay and Anaktalik Bay. Annual landings from the Nain unit have ranged from 16 to 76 t (mean = 50 t, 1974-91). In recent years, 48% of the Nain region catch has originated from the Nain stock unit. In 1991, however, this stock unit contributed only 29% of the total region catch. The recommended Total Allowable Catch (TAC) in 1991 was maintained at 47 t; the same value since 1987.

This paper summarizes information from the 1991 fishery and provides an estimate of current stock size derived from a formulation of the adaptive framework (Gavaris 1988).

2. Trends in catch and effort data - conventional series

Catch and effort data for the Nain stock unit are summarized in Table 1 for the period 1974-91. The highest catch of 76 t occurred in 1977, the lowest catch of 16 t occurred in 1991. TACs listed in Table 1 for 1979 to 1983 applied only to the specific subareas of Anaktalik Bay and Nain-Tikkoatokak Bay. In 1984 and 1985, an offshore component was included in the TAC. The quota area catch in Table 1 summarizes landings for those subareas specifically under quota restrictions only, prior to the derivation of the assessment (stock) units in 1986. Since 1986, the TAC has applied to the entire stock unit.

Landings in 1991 totaled 15.9 t; a 65% drop from the previous year when the 47 t TAC was virtually achieved. Landings had been moderately stable from the mid-1980's until 1990 (coefficient of variation = 12%, 1984-90) and generally close to the recommended TAC (Fig. 2). Effort in 1991 was the lowest recorded and was 21% below 1990. Catch per unit effort (CUE) was 56% less and also the lowest value recorded (Table 1). Catch rates declined substantially in both inshore and offshore zones.

2.1 Timing of the fishery

In 1991, severe ice conditions contributed to the disruption of normal fishing activities along the northern Labrador coast. In many areas, fisherpersons were delayed or prevented from accessing traditional fishing berths. The impact can be seen by comparing average timing of landings in the fishery (Fig. 3). Mean timing of the 1991 commercial charr fishery for the total Nain stock unit was 22 days later (Julian day 229 = August 17) than the average during the past 14 years (Julian day 207 = July 26). The inshore zone had an average catch timing 25 days later in comparison with the 1977 to 1990 period while landings in the offshore zone were 12 days later. Normally peak

return runs of charr to rivers in the Nain area occur during early August (Dempson and Green 1985) suggesting that catches and catch rates in 1991 may have been lower as a result of fish having already returned to the local rivers.

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 1991 data are provided in Table 3. Those ages that contribute to the majority of the catch (ages 7 - 10, 81% of the total catch) appear to have been estimated reasonably with the coefficient of variation less than 10%. The 1981 and 1982 year classes (year of hatching) represented by 9 and 10 year old fish in 1991 were the most abundant representing 48% of the catch (Table 2). These year classes were also the most abundant last year. A summary of the percent at age in the catch is provided in Table 4. Mean age of the catch in 1991 was 9.2 years and has ranged from 8.5 years in 1977 to 9.83 in 1982.

Weights at age were derived from length-weight relationships obtained from sampling the commercial fishery as explained in past years (Dempson 1990). A summary of the relationships used since 1980 are provided in Table 5. 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 less than 0.4% for 1991. Weight at age data are summarized in Table 6. As noted in past assessments, mean weights have declined from the late 1970's and early 1980's but have been relatively stable during the past six years (Table 6).

4. Standardization of catch rates

A multiplicative model (Gavaris 1980) was used to account for differences in catch rates among years and weeks separately for inshore and offshore fishing zones. A combined analysis with classification variables zone, week, and year was also carried out. The regression of ln catch rate for the period 1977 to 1991 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 were obtained using the STANDAR (APL) version of the multiplicative analysis program.

With respect to the inshore zone, the regression of ln catch rate of Arctic charr for the 1977-91 period explained 70% of the variation in the data. Normal probability plots confirmed the general log normal distribution of the data (Fig. 4). Several observations in 1987 and 1989 appeared to have high leverage (Fig. 4) but little influence in the final model as evidenced by the lack of any high DFFITS values (Fig. 4). Both year and week classification

variables were significant (Table 7). Highest catch rates occurred during weeks 31 to 33 (July 30 - August 19) and during the late 1970's and early 1980's (Table 8). The lowest catch rate recorded was in 1991. A comparison of the standardized and unstandardized catch rates for the inshore zone is provided in Fig. 5.

For offshore zone, the regression of ln catch rate of charr for the 1977-91 period explained 75% of the variation in the data. Two observations in 1987 and 1988 appeared to have high leverage (Fig. 6) but influence diagnostics were again reasonably well balanced. Both year and week classification variables were significant (Table 9). Highest catch rates occurred during weeks 30 to 32 (July 23 - August 12) and have been generally increasing over time (Table 8). A comparison of the standardized and unstandardized catch rates for the offshore zone is provided in Fig. 5.

Catch and effort data for the two zones were also analyzed in a combined model with zone included as a classification variable. The regression of ln catch rate of charr for the 1977-91 period in this combined model explained 53% of the variation. Normal probability plots confirmed the log normal distribution of the data (Fig. 7). In the combined model some observations with high leverage identified in the individual analyses were again evident in 1987 and 1989 (Fig. 7) but had little influence as indicated by the well balanced DIFFITS values. All classification variables were significant (Table 10). A comparison of the standardized and unstandardized catch rates for the combined inshore/offshore model is provided in Fig. 5.

Catch rate indices at age were estimated for the inshore (1977-91), offshore (1982-91) (Table 11), and total Nain stock unit (1977-91) (Table 12). Indices were derived using the catch at age of the inshore and offshore and combined total stock unit along with the estimated effort obtained from the standardization of commercial catch rates.

5. Estimation of stock size

Last year, a number of formulations of the ADAPT framework (Gavaris 1988) were run to estimate population size in 1990. These formulations were based on variations of the various catch rate indices used in the calibration process. The accepted formulation was calibrated using the inshore catch rate series from 1977-90 and the offshore catch rate series from 1982-90. 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 abundance indices by age group are closest to the observed values (further details provided in CAFSAC 1988 p. 32).

The ADAPT framework used in this assessment included commercial catch rate data from the inshore (1977-91) and offshore (1982-91) zones, both disaggregated by age. Previously it had been established that intercepts were not significant and thus were not included in the current analysis. The accepted formulation is described as:

Parameters:

- Year-class estimates

  Ni, 1991 i = 6 to 14

- Calibration coefficients for inshore and offshore numbers

  K_1,i i = 6 to 14 (inshore - IN)

  K_2,i i = 6 to 14 (offshore - OFF)

Structure:

- Natural mortality assumed to be 0.2;
- Error in catch at age assumed negligible;
- Fishing mortality (F) for age groups 15-17 set equal to the weighted F for age groups 10-14;
- Intercepts not fitted.

Input data:

Ci,t	i = 6 to 17,	t = 1977-91
INi,t	i = 6 to 14,	t = 1977-91
OFFi,t	i = 6 to 14,	t = 1982-91

Objective function:

- Minimize:

$$\sum_{it} \{obs(lnINi,t) - pred(lnINi,t)\}^2 + \sum_{it} \{obs(lnOFFi,t) - pred(lnOFFi,t)\}^2$$

Summary:

- Number of observations = 225
- Number of parameters = 27

5.1 Assessment Results

Abundances were estimated with coefficients of variation (CV) ranging from 26 to 31% for ages 8 to 14 (Table 13). CVs on the slopes ranged from 16 to 21%. The mean square residual was 0.372. Correlations among parameter estimates were low (Table 14). Residuals for both index series displayed some patterns (Table 15). Predicted values were higher than observed values in the inshore index for 1988-91 but were lower than observed values in the offshore index for 1989-91 (Table 15).

A summary of the estimated population numbers and fishing mortality are provided in Table 16. Fishing mortality in 1991 was estimated to be about 0.22 on age 10+ fish. Using a geometric mean from 1982-89 to estimate age 6 and 7

year old fish in 1991 results in a total estimated population size of about 179,000 fish. The 1990 population size, again using a geometric mean for age 6 fish, was now estimated to be about 186,000 fish, or 3.6% less than the size it was estimated to be last year (Dempson 1991). The assessment suggests that while the estimated population size in 1991 is slightly greater (5%) than it was from 1982-86 (Fig. 8), it has been relatively constant for the past 10 years (mean = 178,370; CV = 6%). In spite of low catch rates experienced by the fishery in 1991, there is no additional evidence to suggest that stock size should decline in the forthcoming year.

5.2 Retrospective analysis

Past assessments have sometimes identified anomalously high recruitment values (age 6 population numbers) in the most recent years. The addition of one or more years of data to the assessment often resulted in a considerable change in the estimated population size for the original terminal year. While unusually high recruitment estimates were not apparent in the current assessment, a retrospective analysis was carried out using the accepted ADAPT formulation to try and identify any pattern associated with this for past years. The retrospective analysis repeated the current assessment by going back as far as 1986. Resulting population sizes are illustrated in Fig. 9. As observed in the figure, in some years (especially 1989) dramatic differences in the estimated stock size occur as new information is added. While this phenomenon occurs, there does not appear to be any appreciable bias associated with it. In some cases the terminal year population size increased with the addition of new data while in other cases it decreased. With the addition of even more years of data, the same pattern of increase or decrease occurred rather than the population size changing continuously in one direction. This may be an artifact of the data used in the calibration process and, as normally used in past assessments, recruitment for the current year or two is obtained by taking a geometric mean from past years.

Also shown in Fig. 9 is the retrospective pattern of population sizes when recruitment is derived using mean values. As expected, there is more stability in the estimation of the current year population size as additional information is added. As indicated above, the population size estimated this year for 1990 is only 3.6% less than was estimated last year. A comparison was made of the population size estimated in the last analytical assessment done in 1987 where the stock size was found to be about 218 thousand fish. The current ADAPT formulation indicates a stock size for 1987 of about 192 thousand fish, a difference of less than 12%.

6. Prognosis

Parameters used for projections of reference level catches were derived from the above ADAPT results and are summarized in Table 17. Weights at age were averages of values from 1988-91. Partial recruitment was obtained by averaging values from the matrix of fishing mortalities for 1982-89. Natural mortality was assumed to be 0.2 while $F_{0.1}$ was again 0.4. Recruitment for the projection was based on the geometric mean population numbers for age 6 fish (1982-89).

Results of the projections suggest the reference level catch for 1992 could be reduced from the current 47 t TAC by about 20% to 37.1 t. Fishing at $F_{0.1}$ could increase the population biomass by about 7% by 1993. Maintaining the current reference level catch at 47 t would increase fishing mortality to over 0.52. However, it is also noted that catches and catch rates in 1991 may have been low as a result of anomalous environmental conditions as evidenced by the later timing of catches in 1991. Thus, it may not be warranted to reduce catches at the present time.

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Table 1. Summary of catch and effort statistics for the Nain assessment unit, 1974-91. Quotas and landings are in kg round weight, effort is expressed as person-weeks fished. Refer to text for information on quotas and quota area catch.

	Inshore			Offshore				Total				
	Catch	Effort	CUE	Catch	Effort	CUE	% Catch offshore	Catch	Effort*	CUE	TAC	Quota area catch
1974	30,822			6,923			18.1	37,745				
1975	31,076			2,754			8.1	33,830				
1976	50,813	146	348	2,500	52	48	4.7	53,313	196	272		
1977	70,908	183	387	5,347	114	47	7.0	76,255	291	262		
1978	70,465	212	332	3,298	106	31	4.5	73,763	314	235		
1979	54,967	189	291	11,877	152	78	17.8	66,844	336	199	61,000	52,832
1980	52,328	183	286	22,727	215	106	30.3	75,055	390	192	61,000	50,176
1981	49,956	157	318	15,676	131	120	23.9	65,632	278	236	37,160	37,223
1982	43,108	119	362	12,509	117	107	22.2	55,617	235	237	43,660	39,119
1983	33,603	147	229	17,599	149	118	34.4	51,202	289	177	51,000	19,102
1984	24,558	131	187	14,342	128	112	36.9	38,900	244	159	43,200	29,063
1985	21,527	125	172	19,631	130	151	47.7	41,158	252	163	30,500	36,019
1986	16,347	91	180	20,748	101	205	55.9	37,095	185	201	43,000	
1987	17,840	71	251	28,032	135	208	61.1	45,872	200	229	47,000	
1988	14,535	90	162	23,759	149	159	62.1	38,295	229	167	47,000	
1989	30,449	103	296	21,016	87	242	40.8	51,465	183	281	47,000	
1990	17,069	88	194	28,205	108	261	62.3	45,275	188	241	47,000	
1991	10,162	102	100	5,730	50	115	36.1	15,892	149	107	47,000	

*Total effort should be equal to or less than the sum of the inshore and offshore effort.

Table 2. Estimated catch at age from the commercial Arctic charr fishery in the Nain stock unit, 1977-91.

CATCH AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
6	2003	371	430	75	145	83	470	182	103	210
7	9250	6703	4306	960	2118	977	2791	2612	2463	4129
8	12453	13122	11568	10519	6877	4782	5842	4619	6506	7713
9	7630	7984	9593	16342	15435	7255	6996	5671	4722	5862
10	5052	4406	4208	8345	9787	7987	4177	4374	4111	2857
11	2454	2367	2168	4077	3746	4936	4357	2173	2494	1284
12	988	1688	1573	1340	991	2976	2762	1495	1605	625
13	358	312	418	813	304	561	600	738	901	240
14	180	272	312	522	151	451	557	281	534	199
15	1	118	34	43	42	59	70	96	322	205
16	1	97	14	1	13	46	27	57	93	50
17	1	1	1	66	10	23	95	89	21	42
6+	40371	37441	34625	43103	39619	30136	28744	22387	23875	23416
7+	38368	37070	34195	43028	39474	30053	28274	22205	23772	23206

AGE	1987	1988	1989	1990	1991
6	483	204	903	459	203
7	5462	6288	4750	4726	1365
8	6293	7166	9707	6115	2085
9	7548	4688	8464	8844	2631
10	4498	3607	3785	4681	2175
11	2013	1631	2853	1908	874
12	1375	650	1234	927	444
13	898	324	665	378	183
14	306	136	277	137	92
15	357	52	28	186	48
16	180	20	6	1	36
17	37	40	1	1	2
6+	29450	24806	32673	28363	10138
7+	28967	24602	31770	27904	9935

Table 3. Summary of catch-at-age data for the Nain stock unit in 1991, with standard error and coefficient of variation (C.V.).

Age	Catch at age	Standard Error	C.V. (%)
6	203	51.1	25.2
7	1365	130.3	9.5
8	2085	157.5	7.5
9	2631	168.7	6.4
10	2175	156.8	7.2
11	874	103.2	11.8
12	444	74.6	16.7
13	183	45.0	24.6
14	92	36.4	39.6
15	48	29.0	60.4
16	36	26.0	72.3
17	2	0	0

Table 4. Summary of the percent at age in the commercial catch of Arctic charr from the Nain stock unit, 1977-91.

PERCENT AT AGE

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	5.0	1.0	1.2	0.2	0.4	0.3	1.6	0.8	0.4	0.9	1.6	0.8
7	22.9	17.9	12.4	2.2	5.3	3.2	9.7	11.7	10.3	17.6	18.5	25.3
8	30.8	35.0	33.4	24.4	17.4	15.9	20.3	20.6	27.3	32.9	21.4	28.9
9	18.9	21.3	27.7	37.9	39.0	24.1	24.3	25.3	19.8	25.0	25.6	18.9
10	12.5	11.8	12.2	19.4	24.7	26.5	14.5	19.5	17.2	12.2	15.3	14.5
11	6.1	6.3	6.3	9.5	9.5	16.4	15.2	9.7	10.4	5.5	6.8	6.6
12	2.4	4.5	4.5	3.1	2.5	9.9	9.6	6.7	6.7	2.7	4.7	2.6
13	0.9	0.8	1.2	1.9	0.8	1.9	2.1	3.3	3.8	1.0	3.0	1.3
14	0.4	0.7	0.9	1.2	0.4	1.5	1.9	1.3	2.2	0.8	1.0	0.5
15	0.0	0.3	0.1	0.1	0.1	0.2	0.2	0.4	1.3	0.9	1.2	0.2
16	0.0	0.3	0.0	0.0	0.0	0.2	0.1	0.3	0.4	0.2	0.6	0.1
17	0.0	0.0	0.0	0.2	0.0	0.1	0.3	0.4	0.1	0.2	0.1	0.2

	1989	1990	1991
6	2.8	1.6	2.0
7	14.5	16.7	13.5
8	29.7	21.6	20.6
9	25.9	31.2	26.0
10	11.6	16.5	21.5
11	8.7	6.7	8.6
12	3.8	3.3	4.4
13	2.0	1.3	1.8
14	0.8	0.5	0.9
15	0.1	0.7	0.5
16	0.0	0.0	0.4
17	0.0	0.0	0.0

Table 5. Summary of slope and intercept parameters from log - log weight length relationship for Arctic charr from the Nain Stock unit.

Year	N	Slope	Intercept	R^2	P
1980	640	3.228	-5.330	0.877	0.0001
1981	736	3.156	-5.215	0.912	0.0001
1982	888	2.894	-4.738	0.852	0.0001
1983	1030	2.911	-4.754	0.851	0.001
1984	1017	2.688	-4.386	0.874	0.0001
1985	1272	2.725	-4.462	0.878	0.0001
1986	1160	2.527	-4.099	0.8573	0.0001
1987	1506	2.537	-4.122	0.8587	0.0001
1988	1635	2.587	-4.218	0.837	0.0001
1989	931	2.523	-4.096	0.807	0.0001
1990	852	2.549	-4.144	0.860	0.0001
1991	889	2.527	-4.128	0.874	0.0001

Table 6. Average weight at age (kg-round) from the commercial Arctic charr fishery, Nain stock unit, 1977-91.

AVERAGE WEIGHT AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	0.89	1.31	1.37	0.89	0.79	1.13	1.27	1.18	1.10	1.15	1.14	1.13
7	1.28	1.71	1.52	1.20	1.18	1.37	1.56	1.40	1.43	1.37	1.33	1.38
8	1.77	1.86	1.85	1.52	1.51	1.68	1.66	1.63	1.65	1.56	1.53	1.55
9	2.07	2.24	2.02	1.78	1.70	1.84	1.84	1.78	1.78	1.69	1.62	1.63
10	2.59	2.41	2.08	1.93	1.76	1.89	1.88	1.88	1.83	1.69	1.65	1.64
11	2.86	2.35	2.18	1.83	1.78	1.93	1.88	1.87	1.81	1.68	1.68	1.67
12	2.74	2.67	2.41	1.91	1.80	1.96	1.92	1.89	1.83	1.70	1.71	1.71
13	3.16	3.34	2.25	1.93	1.74	2.11	1.96	1.93	1.82	1.95	1.68	1.70
14	3.28	2.88	1.94	1.97	1.72	1.93	1.77	2.07	1.90	1.79	1.74	1.44
15	2.65	2.65	2.65	2.71	2.87	2.26	1.84	1.84	1.89	1.61	1.80	1.68
16	2.15	2.15	2.15	2.15	3.88	2.69	2.05	1.46	1.53	1.71	1.61	1.75
17	2.45	2.45	2.45	4.43	2.45	2.69	2.28	1.91	1.64	1.64	2.03	1.75

AGE	1989	1990	1991
6	1.16	1.17	1.29
7	1.38	1.42	1.38
8	1.56	1.50	1.54
9	1.63	1.66	1.59
10	1.71	1.76	1.63
11	1.68	1.68	1.71
12	1.64	1.77	1.70
13	1.69	1.65	1.76
14	1.74	1.75	1.65
15	1.97	1.46	1.66
16	2.56	1.97	1.47
17	1.64	1.81	4.65

MEAN AGE OF INDIVIDUALS IN CATCH

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	8.46	8.75	8.87	9.34	9.28	9.83	9.52	9.40	9.47	8.77	9.10	8.65

AGE	1989	1990	1991
	8.86	8.92	9.16

MEAN WEIGHT OF INDIVIDUALS IN CATCH

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	1.88	2.06	1.93	1.75	1.66	1.85	1.79	1.74	1.73	1.59	1.56	1.55

AGE	1989	1990	1991
	1.58	1.60	1.57

Table 7. Results of the analysis of variance of log transformed catch rate from the inshore zone of the Nain stock unit, 1977-91.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	27	64.24457773	2.37942880	10.85	0.0001	0.695887	9.0223
ERROR	128	28.07577556	0.21934200		ROOT MSE		CUE MEAN
CORRECTED TOTAL	155	92.32035330			0.46833962		5.19090862

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YY	14	32.17104349	10.48	0.0001	14	24.80118108	8.08	0.0001
WK	13	32.07353425	11.25	0.0001	13	32.07353425	11.25	0.0001

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	6.41465605	0.21658523	29.617	0.0001
YY78	1	0.07066024	0.26296105	0.269	0.7886
YY79	1	0.03471464	0.26360989	0.132	0.8954
YY80	1	-0.327523	0.22889785	-1.431	0.1549
YY81	1	-0.277271	0.23264350	-1.192	0.2355
YY82	1	-0.0697157	0.22867050	-0.305	0.7610
YY83	1	-0.561271	0.22598672	-2.484	0.0143
YY84	1	-0.665772	0.23248903	-2.864	0.0049
YY85	1	-0.628758	0.22598672	-2.782	0.0062
YY86	1	-1.07882	0.22867050	-4.718	0.0001
YY87	1	-0.487209	0.22685707	-2.148	0.0336
YY88	1	-1.06945	0.22305721	-4.795	0.0001
YY89	1	-0.875973	0.22538759	-3.887	0.0002
YY90	1	-0.964029	0.22867050	-4.216	0.0001
YY91	1	-1.30513	0.23050737	-5.662	0.0001
WK24	1	-1.80098	0.37105136	-4.854	0.0001
WK25	1	-0.757521	0.21858377	-3.466	0.0007
WK26	1	-0.69171	0.18604421	-3.718	0.0003
WK27	1	-0.687471	0.18274047	-3.762	0.0003
WK28	1	-0.666249	0.18274047	-3.646	0.0004
WK29	1	-0.802251	0.18274047	-4.390	0.0001
WK30	1	-0.605084	0.18274047	-3.311	0.0012
WK32	1	0.05171568	0.18779471	0.275	0.7835
WK33	1	-0.0184541	0.19211917	-0.096	0.9236
WK34	1	-0.540583	0.18897078	-2.861	0.0049
WK35	1	-0.826395	0.19689644	-4.197	0.0001
WK36	1	-1.40527	0.23924027	-5.874	0.0001
WK37	1	-2.12622	0.25555598	-8.320	0.0001

Table 8. Standardized catch rates (C/E) and standard errors (SE) for the inshore and offshore zones, and combined catch rate for the Nain stock unit, 1977-91.

	Inshore		Offshore		Total (combined)		
	C/E	SE	C/E	SE	C/E	SE	Effort
1977	666	143	68	14	306	62	249
1978	711	169	54	12	277	60	266
1979	686	164	133	28	429	92	156
1980	483	92	173	35	469	88	160
1981	507	99	196	41	499	96	131
1982	624	119	183	38	563	106	99
1983	382	72	199	40	443	82	116
1984	344	67	238	46	443	82	88
1985	357	67	303	59	513	94	80
1986	228	43	297	62	385	73	96
1987	411	78	299	58	525	97	87
1988	230	42	240	48	347	63	111
1989	279	54	373	76	489	92	105
1990	255	49	293	58	421	78	108
1991	182	35	235	54	300	59	53

Table 9. Results of the analysis of variance of log transformed catch rate from the offshore zone of the Nain stock unit, 1977-91.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	25	74.72194712	2.98887788	12.75	0.0001	0.748609	10.6864
ERROR	107	25.09249150	0.23450927		ROOT MSE		CUE MEAN
CORRECTED TOTAL	132	99.81443862			0.48426157		4.53155123

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YY	14	34.15281706	10.40	0.0001	14	31.27014894	9.52	0.0001
WK	11	40.56913005	15.73	0.0001	11	40.56913005	15.73	0.0001

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	4.11932404	0.21101925	19.521	0.0001
YY78	1	-0.222146	0.25124969	-0.884	0.3786
YY79	1	0.67384067	0.24578053	2.742	0.0072
YY80	1	0.93627744	0.23585890	3.970	0.0001
YY81	1	1.06104241	0.24578053	4.317	0.0001
YY82	1	0.99464631	0.24411010	4.075	0.0001
YY83	1	1.07681146	0.23805180	4.523	0.0001
YY84	1	1.25297685	0.22752606	5.507	0.0001
YY85	1	1.49500743	0.23094691	6.473	0.0001
YY86	1	1.47980740	0.24411010	6.062	0.0001
YY87	1	1.48218257	0.23145800	6.404	0.0001
YY88	1	1.26335315	0.23528641	5.369	0.0001
YY89	1	1.70601029	0.24054123	7.092	0.0001
YY90	1	1.46382877	0.23385867	6.259	0.0001
YY91	1	1.24810995	0.25251947	4.943	0.0001
WK25	1	-2.32634	0.38067844	-6.111	0.0001
WK26	1	-0.725689	0.28308827	-2.563	0.0118
WK27	1	-1.02166	0.20979361	-4.870	0.0001
WK28	1	-1.07622	0.18797306	-5.725	0.0001
WK29	1	-0.699222	0.18398493	-3.800	0.0002
WK30	1	-0.267626	0.18303367	-1.462	0.1466
WK32	1	-0.0754327	0.18040989	-0.418	0.6767
WK33	1	-0.351533	0.18040989	-1.949	0.0540
WK34	1	-0.815527	0.18040989	-4.520	0.0001
WK35	1	-1.37095	0.19247251	-7.123	0.0001
WK36	1	-2.07415	0.24409641	-8.497	0.0001

Table 10. Results of the analysis of variance of log transformed catch rate from the Nain stock unit, 1977-91.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	28	119.21882441	4.25781516	10.63	0.0001	0.533784	12.9483
ERROR	260	104.12786352	0.40049178		ROOT MSE		CUE MEAN
CORRECTED TOTAL	288	223.34668793			0.63284420		4.88746733

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YY	14	16.11220293	2.87	0.0005	14	11.50619119	2.05	0.0148
ZN	1	30.94964641	77.28	0.0001	1	40.33338086	100.71	0.0001
WK	13	72.15697507	13.86	0.0001	13	72.15697507	13.86	0.0001

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	5.54396150	0.20429557	27.137	0.0001
YY78	1	-0.0959288	0.24036243	-0.399	0.6901
YY79	1	0.33961408	0.23687571	1.434	0.1529
YY80	1	0.42424624	0.21670066	1.958	0.0513
YY81	1	0.48691645	0.22248398	2.189	0.0295
YY82	1	0.60683302	0.21968227	2.762	0.0061
YY83	1	0.36544001	0.21487366	1.701	0.0902
YY84	1	0.36571943	0.21435689	1.706	0.0892
YY85	1	0.51313281	0.21279898	2.411	0.0166
YY86	1	0.22689380	0.21968227	1.033	0.3026
YY87	1	0.53638038	0.21253189	2.524	0.0122
YY88	1	0.11981911	0.21163424	0.566	0.5718
YY89	1	0.46627506	0.21422374	2.177	0.0304
YY90	1	0.31525519	0.21493517	1.467	0.1437
YY91	1	-0.0208427	0.22322044	-0.093	0.9257
ZN2	1	-0.777021	0.07742783	-10.035	0.0001
WK24	1	-2.11321	0.47572316	-4.442	0.0001
WK25	1	-1.08389	0.24024943	-4.512	0.0001
WK26	1	-0.574282	0.19648622	-2.923	0.0038
WK27	1	-0.715165	0.18023986	-3.968	0.0001
WK28	1	-0.743223	0.17282317	-4.300	0.0001
WK29	1	-0.665386	0.17121039	-3.886	0.0001
WK30	1	-0.403155	0.17124387	-2.354	0.0193
WK32	1	-0.0110502	0.17250905	-0.064	0.9490
WK33	1	-0.230199	0.17417583	-1.322	0.1874
WK34	1	-0.676575	0.17273601	-3.917	0.0001
WK35	1	-1.15541	0.18193346	-6.351	0.0001
WK36	1	-1.88753	0.22426779	-8.416	0.0001
WK37	1	-2.4324	0.31647927	-7.686	0.0001

Table 11. Catch rate indices for the inshore and offshore zones of the Nain stock unit, used in the ADAPT calibration process.

NAIN UNIT INSHORE COMMERCIAL CATCH RATE AT AGE

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	17.6	3.6	4.4	0.5	1.1	1.0	2.5	1.0	0.2	1.5	4.7
7	81.1	64.7	44.3	6.3	16.3	7.7	18.2	19.3	15.6	24.4	47.0
8	109.2	126.6	118.9	67.9	52.9	49.7	38.7	35.5	44.9	46.3	50.2
9	66.9	77.0	98.6	105.5	118.7	86.1	49.6	49.3	40.1	34.7	65.1
10	44.3	42.5	43.3	53.9	75.3	88.6	31.4	43.7	40.3	16.7	42.4
11	21.5	22.8	22.3	26.3	28.8	58.8	31.7	20.1	24.4	7.6	20.5
12	8.7	16.3	16.2	8.6	7.6	34.8	23.4	14.4	16.0	4.5	13.2
13	3.1	3.0	4.3	5.3	2.3	6.1	5.0	6.3	8.4	1.7	9.7
14	1.6	2.6	3.2	3.4	1.2	4.7	4.1	1.3	5.1	1.5	3.5

	1988	1989	1990	1991
6	1.3	5.3	3.2	2.4
7	39.8	28.1	29.3	16.3
8	43.8	52.3	33.4	21.6
9	26.9	46.4	48.1	30.6
10	19.9	19.0	24.8	24.7
11	9.3	14.7	11.5	9.6
12	3.7	5.5	5.1	4.1
13	2.3	2.5	1.9	2.0
14	1.0	1.6	0.8	1.3

NAIN UNIT OFFSHORE COMMERCIAL CATCH RATE AT AGE

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
6	0.3	3.1	1.5	2.6	0.4	2.1	1.0	6.8	1.9	2.3
7	12.1	13.4	16.9	31.3	34.2	41.2	34.7	30.9	25.5	15.2
8	22.6	29.0	33.5	73.4	61.6	60.7	43.3	71.4	40.9	38.1
9	12.9	32.8	36.4	35.3	51.6	56.1	32.0	60.8	59.7	36.8
10	31.3	16.2	22.6	20.0	26.6	24.9	26.6	30.8	33.9	33.7
11	10.0	19.3	13.4	10.4	10.7	5.7	11.5	21.8	11.0	13.8
12	9.1	5.5	8.2	5.6	1.9	7.1	4.5	11.9	6.4	9.9
13	1.6	1.9	5.2	5.2	1.0	1.6	1.5	7.8	2.8	2.9
14	1.4	2.4	2.7	2.6	0.5	0.0	0.5	2.0	0.9	0.5

Table 12. Catch rate index for the Nain stock unit (inshore and offshore zones combined), 1977-91.

NAIN UNIT (INSHORE + OFFSHORE) COMMERCIAL CATCH RATE AT AGE

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	8.0	1.4	2.8	0.5	1.1	0.8	4.1	2.1	1.3	2.2	5.6	1.8
7	37.1	25.2	27.6	6.0	16.2	9.9	24.1	29.7	30.8	43.0	62.8	56.6
8	50.0	49.3	74.2	65.7	52.5	48.3	50.4	52.5	81.3	80.3	72.3	64.6
9	30.6	30.0	61.5	102.1	117.8	73.3	60.3	64.4	59.0	61.1	86.8	42.2
10	20.3	16.6	27.0	52.2	74.7	80.7	36.0	49.7	51.4	29.8	51.7	32.5
11	9.9	8.9	13.9	25.5	28.6	49.9	37.6	24.7	31.2	13.4	23.1	14.7
12	4.0	6.3	10.1	8.4	7.6	30.1	23.8	17.0	20.1	6.5	15.8	5.9
13	1.4	1.2	2.7	5.1	2.3	5.7	5.2	8.4	11.3	2.5	10.3	2.9
14	0.7	1.0	2.0	3.3	1.2	4.6	4.8	3.2	6.7	2.1	3.5	1.2

	1989	1990	1991
6	8.6	4.2	3.8
7	45.2	43.8	25.8
8	92.4	56.6	39.3
9	80.6	81.9	49.6
10	36.0	43.3	41.0
11	27.2	17.7	16.5
12	11.8	9.6	8.4
13	6.3	3.5	3.5
14	2.6	1.3	1.7

Table 13. Parameter estimates from ADAPT using inshore (1977-91) and offshore (1982-91) catch rates, ages 6-14, in a single analysis.

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET,..... 0.048621
MEAN SQUARE RESIDUALS 0.371896

AGE	PARAMETER	ESTIMATE	STD. ERR.	T-STATISTIC	C.V.
6	ABUNDANCE	7.82583E4	3.53775E4	2.21209E0	0.45
7	ABUNDANCE	4.49646E4	1.43371E4	3.13625E0	0.32
8	ABUNDANCE	4.37801E4	1.19118E4	3.67535E0	0.27
9	ABUNDANCE	1.69402E4	4.50690E3	3.75872E0	0.27
10	ABUNDANCE	1.28130E4	3.37838E3	3.79265E0	0.26
11	ABUNDANCE	4.54678E3	1.37343E3	3.31052E0	0.30
12	ABUNDANCE	2.11192E3	6.33245E2	3.33507E0	0.30
13	ABUNDANCE	1.01249E3	3.16570E2	3.19830E0	0.31
14	ABUNDANCE	4.15769E2	1.27786E2	3.25363E0	0.31
6	RV1 SLOPE	3.66022E-5	6.02052E-6	6.07958E0	0.16
7	RV1 SLOPE	5.57042E-4	8.98995E-5	6.19628E0	0.16
8	RV1 SLOPE	1.70532E-3	2.73302E-4	6.23968E0	0.16
9	RV1 SLOPE	3.19753E-3	5.12058E-4	6.24448E0	0.16
10	RV1 SLOPE	3.85929E-3	6.18898E-4	6.23574E0	0.16
11	RV1 SLOPE	4.17837E-3	6.72153E-4	6.21639E0	0.16
12	RV1 SLOPE	4.65535E-3	7.49242E-4	6.21342E0	0.16
13	RV1 SLOPE	3.89192E-3	6.26595E-4	6.21123E0	0.16
14	RV1 SLOPE	5.08294E-3	8.17535E-4	6.21740E0	0.16
6	RV2 SLOPE	3.03409E-5	6.23674E-6	4.86486E0	0.21
7	RV2 SLOPE	6.16785E-4	1.23366E-4	4.99966E0	0.20
8	RV2 SLOPE	1.69257E-3	3.35082E-4	5.05122E0	0.20
9	RV2 SLOPE	2.57262E-3	5.08712E-4	5.05713E0	0.20
10	RV2 SLOPE	3.17393E-3	6.28858E-4	5.04713E0	0.20
11	RV2 SLOPE	2.89142E-3	5.75525E-4	5.02397E0	0.20
12	RV2 SLOPE	3.13978E-3	6.25389E-4	5.02052E0	0.20
13	RV2 SLOPE	2.71142E-3	5.40368E-4	5.01773E0	0.20
14	RV2 SLOPE	1.80607E-3	3.59402E-4	5.02522E0	0.20

Table 14. Parameter correlation matrix from ADAPT using inshore (1977-91) and offshore (1982-91) zone catch rates, ages 6-14, in a single analysis.

PARAMETER CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10
1	1.000	0.072	0.060	0.046	0.032	0.019	0.015	0.010	0.008	-0.204
2	0.072	1.000	0.083	0.064	0.045	0.027	0.021	0.014	0.011	-0.158
3	0.060	0.083	1.000	0.081	0.058	0.034	0.027	0.017	0.013	-0.132
4	0.046	0.064	0.081	1.000	0.075	0.045	0.034	0.022	0.017	-0.101
5	0.032	0.045	0.058	0.075	1.000	0.015	0.033	0.047	0.071	-0.072
6	0.019	0.027	0.034	0.045	0.015	1.000	0.064	0.050	0.047	-0.043
7	0.015	0.021	0.027	0.034	0.033	0.064	1.000	0.072	0.051	-0.034
8	0.010	0.014	0.017	0.022	0.047	0.050	0.072	1.000	0.073	-0.022
9	0.008	0.011	0.013	0.017	0.071	0.047	0.051	0.073	1.000	-0.017
10	-0.204	-0.158	-0.132	-0.101	-0.072	-0.043	-0.034	-0.022	-0.017	1.000
11	-0.022	-0.152	-0.130	-0.101	-0.072	-0.043	-0.034	-0.021	-0.017	0.049
12	-0.015	-0.021	-0.130	-0.115	-0.081	-0.048	-0.038	-0.024	-0.019	0.033
13	-0.011	-0.015	-0.019	-0.134	-0.110	-0.066	-0.048	-0.032	-0.024	0.024
14	-0.008	-0.011	-0.014	-0.018	-0.141	-0.109	-0.071	-0.045	-0.036	0.017
15	-0.006	-0.008	-0.010	-0.013	-0.030	-0.162	-0.116	-0.072	-0.045	0.013
16	-0.005	-0.007	-0.009	-0.011	-0.046	-0.031	-0.162	-0.122	-0.071	0.011
17	-0.005	-0.007	-0.009	-0.011	-0.074	-0.039	-0.032	-0.166	-0.120	0.011
18	-0.006	-0.008	-0.010	-0.013	-0.116	-0.055	-0.036	-0.033	-0.167	0.013
19	-0.245	-0.190	-0.158	-0.121	-0.084	-0.051	-0.040	-0.026	-0.020	0.100
20	-0.027	-0.184	-0.157	-0.122	-0.087	-0.052	-0.041	-0.026	-0.020	0.059
21	-0.018	-0.025	-0.158	-0.139	-0.099	-0.058	-0.046	-0.029	-0.022	0.040
22	-0.013	-0.018	-0.023	-0.163	-0.133	-0.080	-0.058	-0.038	-0.029	0.029
23	-0.009	-0.013	-0.016	-0.021	-0.171	-0.132	-0.085	-0.055	-0.043	0.021
24	-0.007	-0.010	-0.013	-0.016	-0.036	-0.196	-0.141	-0.087	-0.054	0.016
25	-0.006	-0.008	-0.011	-0.014	-0.055	-0.038	-0.197	-0.147	-0.086	0.013
26	-0.006	-0.008	-0.010	-0.013	-0.089	-0.047	-0.038	-0.201	-0.145	0.013
27	-0.007	-0.010	-0.013	-0.016	-0.140	-0.067	-0.044	-0.040	-0.202	0.016

	11	12	13	14	15	16	17	18	19	20
1	-0.022	-0.015	-0.011	-0.008	-0.006	-0.005	-0.005	-0.006	-0.245	-0.027
2	-0.152	-0.021	-0.015	-0.011	-0.008	-0.007	-0.007	-0.008	-0.190	-0.184
3	-0.130	-0.130	-0.019	-0.014	-0.010	-0.009	-0.009	-0.010	-0.158	-0.157
4	-0.101	-0.115	-0.134	-0.018	-0.013	-0.011	-0.011	-0.013	-0.121	-0.122
5	-0.072	-0.081	-0.110	-0.141	-0.030	-0.046	-0.074	-0.116	-0.084	-0.087
6	-0.043	-0.048	-0.066	-0.109	-0.162	-0.031	-0.039	-0.055	-0.051	-0.052
7	-0.034	-0.038	-0.048	-0.071	-0.116	-0.162	-0.032	-0.036	-0.040	-0.041
8	-0.021	-0.024	-0.032	-0.045	-0.072	-0.122	-0.166	-0.033	-0.026	-0.026
9	-0.017	-0.019	-0.024	-0.036	-0.045	-0.071	-0.120	-0.167	-0.020	-0.020
10	0.049	0.033	0.024	0.017	0.013	0.011	0.011	0.013	0.100	0.059
11	1.000	0.032	0.023	0.017	0.013	0.011	0.011	0.013	0.059	0.058
12	0.032	1.000	0.027	0.019	0.014	0.012	0.012	0.015	0.039	0.039
13	0.023	0.027	1.000	0.025	0.019	0.016	0.016	0.019	0.028	0.028
14	0.017	0.019	0.025	1.000	0.030	0.023	0.022	0.027	0.020	0.020
15	0.013	0.014	0.019	0.030	1.000	0.031	0.023	0.021	0.015	0.016
16	0.011	0.012	0.016	0.023	0.031	1.000	0.031	0.022	0.013	0.013
17	0.011	0.012	0.016	0.022	0.023	0.031	1.000	0.031	0.013	0.013
18	0.013	0.015	0.019	0.027	0.021	0.022	0.031	1.000	0.015	0.016
19	0.059	0.039	0.028	0.020	0.015	0.013	0.013	0.015	1.000	0.071
20	0.058	0.039	0.028	0.020	0.016	0.013	0.013	0.016	0.071	1.000
21	0.039	0.042	0.032	0.023	0.018	0.015	0.014	0.018	0.047	0.048
22	0.028	0.032	0.040	0.031	0.023	0.020	0.019	0.024	0.034	0.034
23	0.020	0.023	0.031	0.043	0.036	0.028	0.027	0.033	0.024	0.025
24	0.016	0.017	0.023	0.036	0.051	0.037	0.028	0.025	0.018	0.019
25	0.013	0.015	0.020	0.028	0.037	0.052	0.038	0.027	0.016	0.016
26	0.013	0.014	0.019	0.027	0.028	0.038	0.053	0.037	0.015	0.016
27	0.016	0.018	0.024	0.033	0.025	0.027	0.037	0.050	0.018	0.019

Table 14. continued.

	21	22	23	24	25	26	27
1	-0.018	-0.013	-0.009	-0.007	-0.006	-0.006	-0.007
2	-0.025	-0.018	-0.013	-0.010	-0.008	-0.008	-0.010
3	-0.158	-0.023	-0.016	-0.013	-0.011	-0.010	-0.013
4	-0.139	-0.163	-0.021	-0.016	-0.014	-0.013	-0.016
5	-0.099	-0.133	-0.171	-0.036	-0.055	-0.089	-0.140
6	-0.058	-0.080	-0.132	-0.196	-0.038	-0.047	-0.067
7	-0.046	-0.058	-0.085	-0.141	-0.197	-0.038	-0.044
8	-0.029	-0.038	-0.055	-0.087	-0.147	-0.201	-0.040
9	-0.022	-0.029	-0.043	-0.054	-0.086	-0.145	-0.202
10	0.040	0.029	0.021	0.016	0.013	0.013	0.016
11	0.039	0.028	0.020	0.016	0.013	0.013	0.016
12	0.042	0.032	0.023	0.017	0.015	0.014	0.018
13	0.032	0.040	0.031	0.023	0.020	0.019	0.024
14	0.023	0.031	0.043	0.036	0.028	0.027	0.033
15	0.018	0.023	0.036	0.051	0.037	0.028	0.025
16	0.015	0.020	0.028	0.037	0.052	0.038	0.027
17	0.014	0.019	0.027	0.028	0.038	0.053	0.037
18	0.018	0.024	0.033	0.025	0.027	0.037	0.050
19	0.047	0.034	0.024	0.018	0.016	0.015	0.018
20	0.048	0.034	0.025	0.019	0.016	0.016	0.019
21	1.000	0.039	0.028	0.021	0.018	0.017	0.021
22	0.039	1.000	0.037	0.028	0.024	0.023	0.028
23	0.028	0.037	1.000	0.044	0.034	0.033	0.039
24	0.021	0.028	0.044	1.000	0.045	0.033	0.030
25	0.018	0.024	0.034	0.045	1.000	0.046	0.032
26	0.017	0.023	0.033	0.033	0.046	1.000	0.045
27	0.021	0.028	0.039	0.030	0.032	0.045	1.000

Table 15. Residuals from ADAPT using inshore (1977-91) and offshore (1982-91) zone catch rates, ages 6-14, in a single analysis.

LOG RESIDUALS FOR INSHORE INDEX

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
6	1.475	0.073	0.918	-1.226	-0.322	-0.338	0.383	-0.666	-1.907	-0.284
7	0.704	0.304	0.098	-1.238	-0.216	-0.912	0.105	-0.037	-0.368	0.285
8	0.565	0.430	0.127	-0.261	0.110	0.101	-0.083	0.014	0.056	-0.028
9	0.206	0.149	0.050	-0.106	0.229	0.516	-0.020	0.040	0.007	-0.303
10	0.098	0.237	-0.047	-0.118	0.050	0.485	-0.003	0.357	0.302	-0.465
11	-0.090	0.014	0.212	0.107	-0.122	0.459	0.204	0.196	0.517	-0.823
12	0.212	0.242	0.272	-0.063	-0.505	0.844	0.249	0.119	0.854	-0.546
13	0.306	0.071	-0.263	0.170	-0.508	0.010	-0.044	-0.142	0.598	-0.277
14	-0.503	1.052	0.817	-0.069	-0.937	0.802	0.114	-1.040	0.048	-0.669

	1987	1988	1989	1990	1991
6	0.703	-0.150	0.801	0.575	-0.062
7	0.706	0.374	0.438	0.039	-0.311
8	0.292	-0.090	-0.059	-0.091	-1.111
9	0.260	-0.439	-0.065	-0.179	-0.372
10	0.414	-0.458	-0.320	-0.078	-0.484
11	0.360	-0.441	-0.039	-0.129	-0.453
12	0.285	-0.776	-0.247	-0.327	-0.643
13	1.583	-0.635	-0.198	-0.237	-0.461
14	1.391	0.681	-0.706	-0.786	-0.223

SUM OF INDEX 1 RESIDUALS : -0.2528785003 MEAN RESIDUAL : -0.0018731741

LOG RESIDUALS FOR OFFSHORE INDEX

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
6	-1.465	0.797	0.003	0.709	-1.383	0.058	-0.272	1.230	0.227	0.068
7	-0.557	-0.304	-0.272	0.229	0.519	0.473	0.135	0.433	-0.203	-0.482
8	-0.679	-0.365	-0.039	0.555	0.264	0.488	-0.096	0.261	0.119	-0.536
9	-1.162	-0.216	-0.046	0.097	0.313	0.328	-0.048	0.423	0.255	0.030
10	-0.358	-0.468	-0.107	-0.203	0.199	0.075	0.029	0.354	0.431	0.020
11	-0.949	0.073	0.162	0.030	-0.119	-0.548	0.132	0.727	0.193	0.270
12	-0.107	-0.806	-0.054	0.208	-0.996	0.068	-0.202	0.920	0.303	0.637
13	-0.970	-0.678	0.026	0.485	-0.401	0.133	-0.705	1.293	0.512	0.277
14	0.594	0.590	0.724	0.430	-0.623	-3.367	0.912	0.601	0.359	-0.247

SUM OF INDEX 2 RESIDUALS : -0.2527697859 MEAN RESIDUAL : -0.0028085532

Table 16. Estimated population numbers and fishing mortality from ADAPT using inshore (1977-91) and offshore (1982-91) catch rates, ages 6-14, in a single analysis.

POPULATION NUMBERS

	1977	1978	1979	1980	1981	1982	1983	1984	1985
6	122467	100565	53579	50522	47223	41774	50808	56370	47514
7	84870	98456	82000	43477	41296	38532	34127	41173	45987
8	47685	61116	74543	63240	34728	31894	30663	25415	31346
9	23505	27773	38164	50564	42258	22210	21786	19819	16629
10	14628	12340	15514	22566	26611	20632	11619	11506	11095
11	7730	7405	6116	8895	10925	12932	9665	5734	5463
12	2298	4108	3921	3046	3593	5555	6121	3971	2728
13	884	987	1836	1787	1281	2045	1855	2513	1898
14	675	400	526	1125	728	774	1167	976	1389
15	137	390	81	148	449	459	226	451	545
16	4	111	212	36	82	329	322	121	283
17	3	3	3	161	28	56	228	240	48
6+	304886	313654	276497	245567	209203	177192	168588	168289	164925

	1986	1987	1988	1989	1990	1991
6	60268	71206	47438	72522	55305	78124
7	38808	49153	57861	38655	58559	44864
8	35423	28037	35301	41683	27350	43668
9	19777	22023	17261	22418	25344	16859
10	9342	10888	11201	9890	10696	12748
11	5364	5063	4844	5907	4673	4521
12	2216	3230	2324	2490	2255	2099
13	781	1249	1400	1315	922	1007
14	739	423	210	853	475	413
15	654	425	69	49	448	265
16	155	350	25	9	15	198
17	147	81	124	2	2	11
6+	173674	192127	178058	195794	186042	204778

FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	0.018	0.004	0.009	0.002	0.003	0.002	0.010	0.004	0.002	0.004	0.008
7	0.128	0.078	0.060	0.025	0.058	0.028	0.095	0.073	0.061	0.125	0.131
8	0.341	0.271	0.188	0.203	0.247	0.181	0.236	0.224	0.261	0.275	0.285
9	0.444	0.382	0.325	0.442	0.517	0.448	0.438	0.380	0.377	0.397	0.476
10	0.481	0.502	0.356	0.525	0.522	0.558	0.506	0.545	0.527	0.412	0.610
11	0.432	0.436	0.497	0.706	0.476	0.548	0.690	0.543	0.702	0.307	0.579
12	0.645	0.605	0.586	0.666	0.364	0.897	0.690	0.538	1.050	0.374	0.636
13	0.593	0.430	0.290	0.699	0.304	0.361	0.442	0.392	0.743	0.415	1.584
14	0.349	1.393	1.066	0.719	0.261	1.033	0.750	0.383	0.553	0.353	1.611
15	0.008	0.407	0.620	0.386	0.109	0.153	0.420	0.268	1.059	0.425	2.638
16	0.285	3.363	0.076	0.031	0.191	0.168	0.097	0.732	0.452	0.442	0.839
17	0.480	0.510	0.428	0.593	0.486	0.599	0.607	0.521	0.652	0.375	0.685

	1988	1989	1990	1991
6	0.005	0.014	0.009	0.003
7	0.128	0.146	0.093	0.034
8	0.254	0.298	0.284	0.054
9	0.357	0.540	0.487	0.188
10	0.440	0.550	0.661	0.208
11	0.465	0.763	0.600	0.239
12	0.370	0.793	0.606	0.264
13	0.295	0.819	0.603	0.223
14	1.260	0.444	0.384	0.280
15	1.785	1.008	0.614	0.222
16	2.193	1.201	0.079	0.222
17	0.436	0.654	0.630	0.222

Table 17. Parameters used as input for the reference level catch projections of the Nain Stock Unit.

Age	Mean Weight (kg)	Population Numbers	Partial Recruitment
6	1.19	55016	0.010
7	1.39	42489	0.182
8	1.54	43668	0.454
9	1.63	16859	0.734
10	1.69	12748	0.868
11	1.68	4521	1.0
12	1.71	2099	1.0
13	1.70	1007	1.0
14	1.65	413	1.0
15	1.69	265	1.0
16	1.94	198	1.0
17	2.46	11	1.0

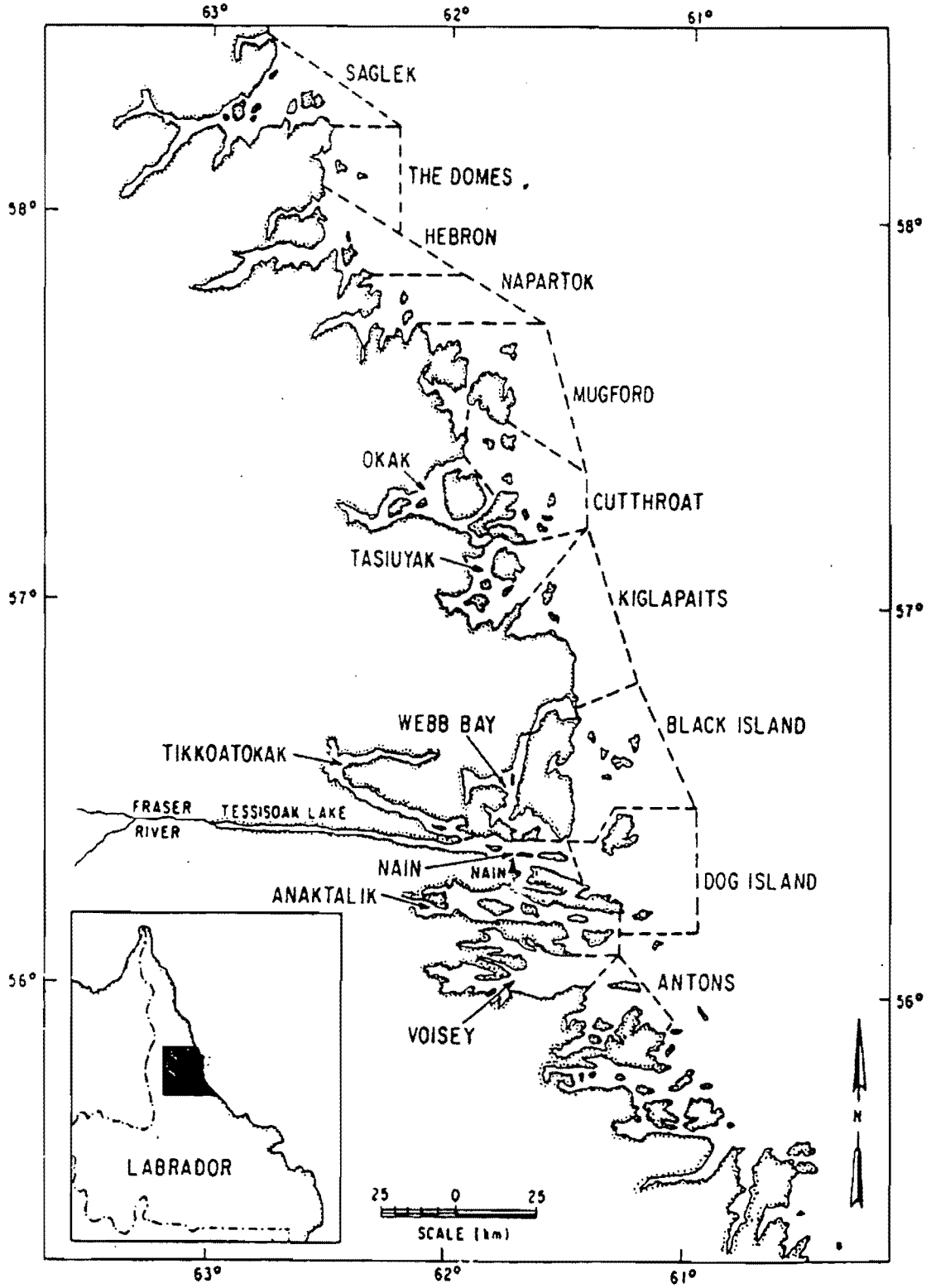


Figure 1. Geographical separation of the Nain Fishing Region subareas.

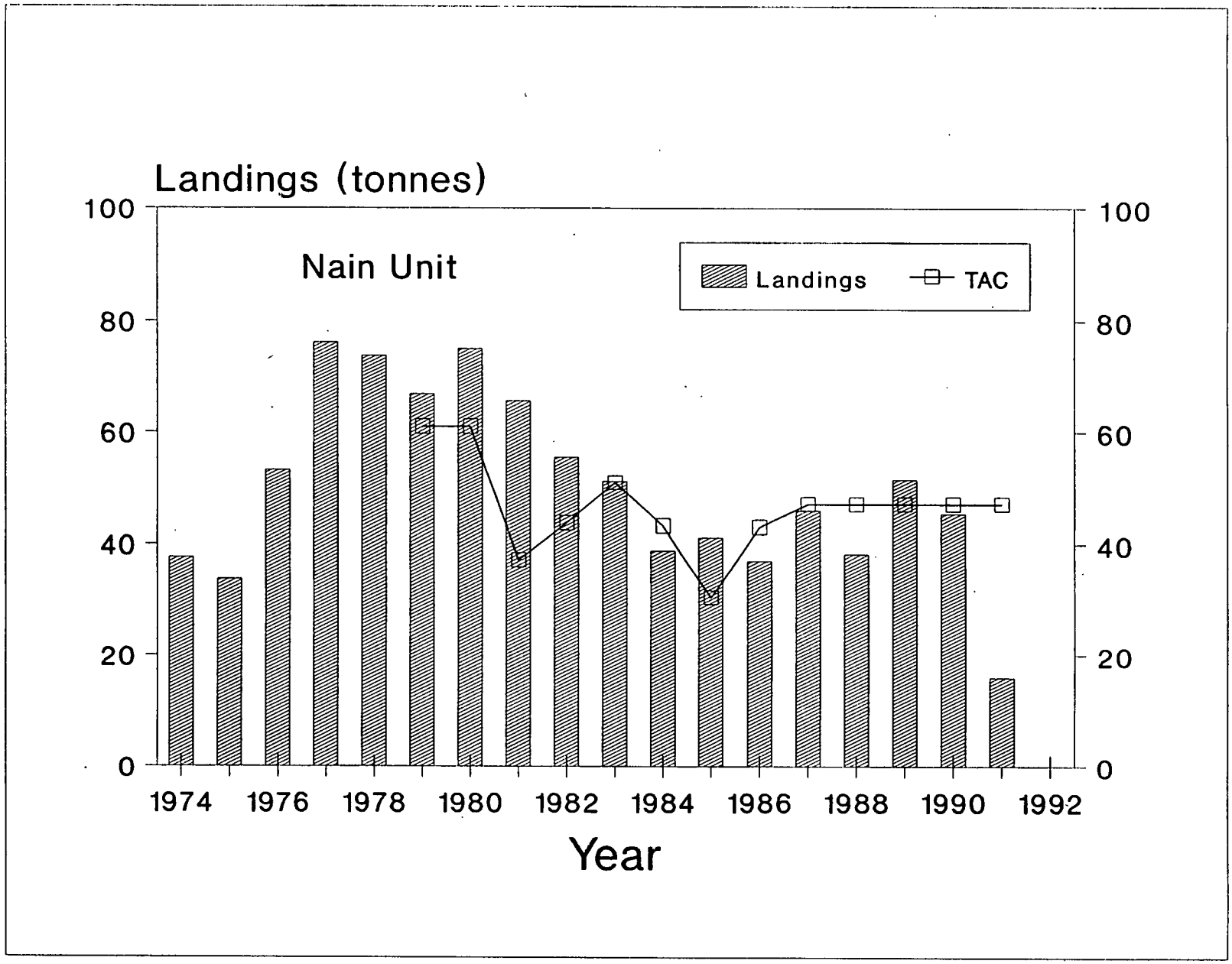


Fig. 2. Summary of Arctic charr landings from the Nain stock unit in relation to the TAC.

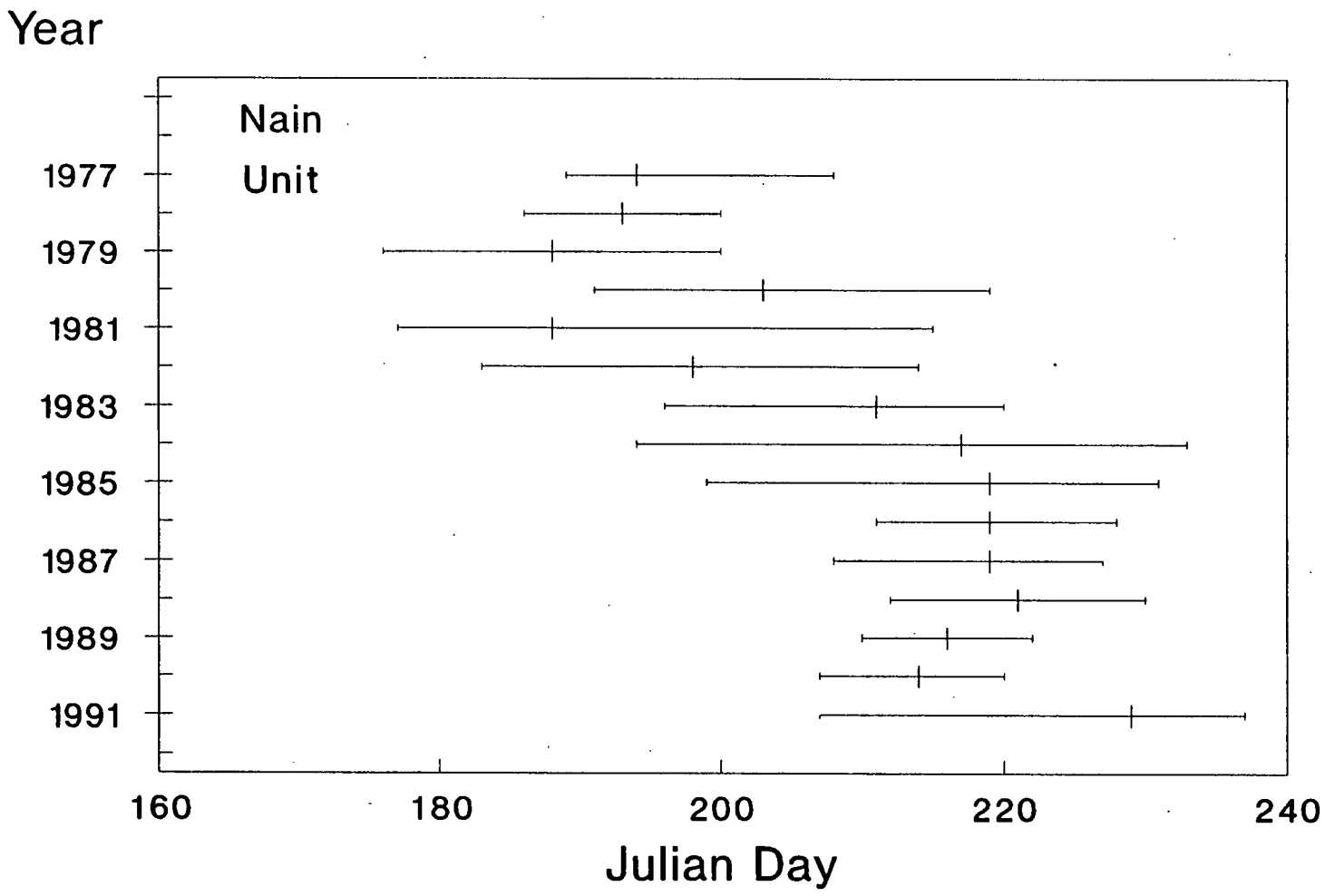
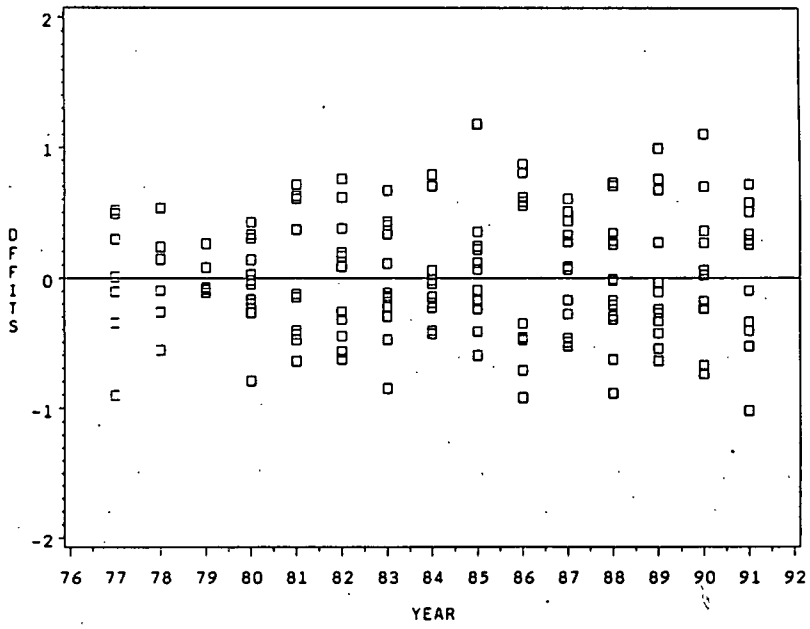
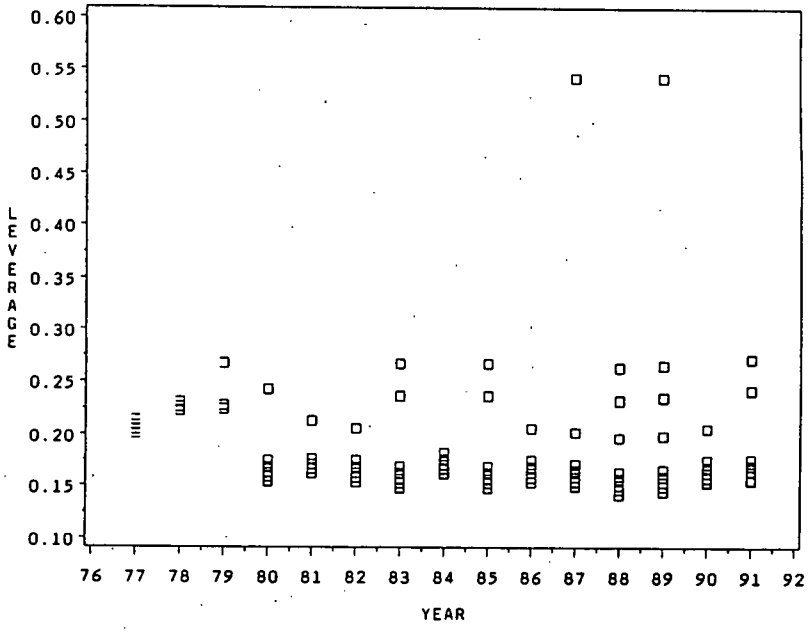
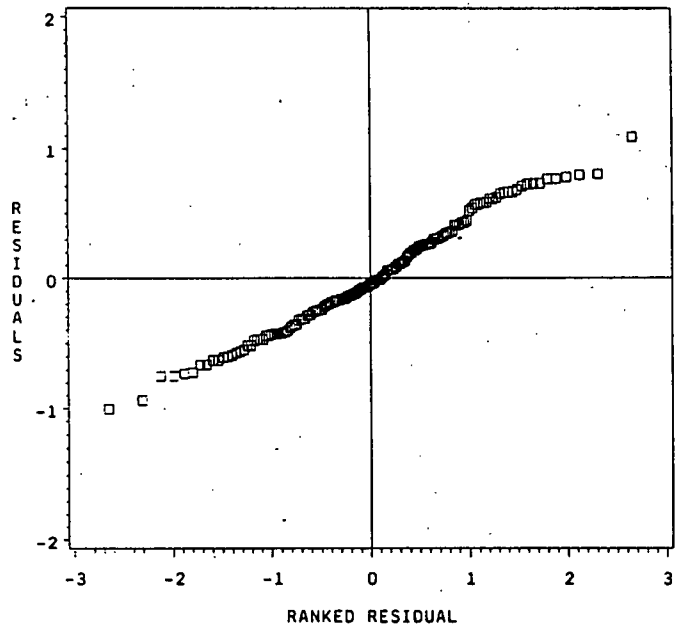


Fig. 3. Catch timing of the Nain stock unit Arctic charr commercial fishery, 1977-91. The median point, along with the 25th and 75th percentiles are illustrated.







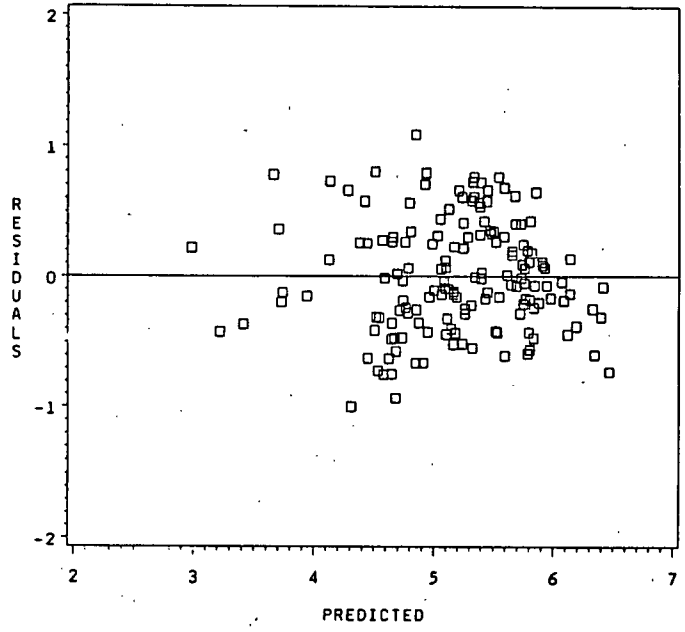
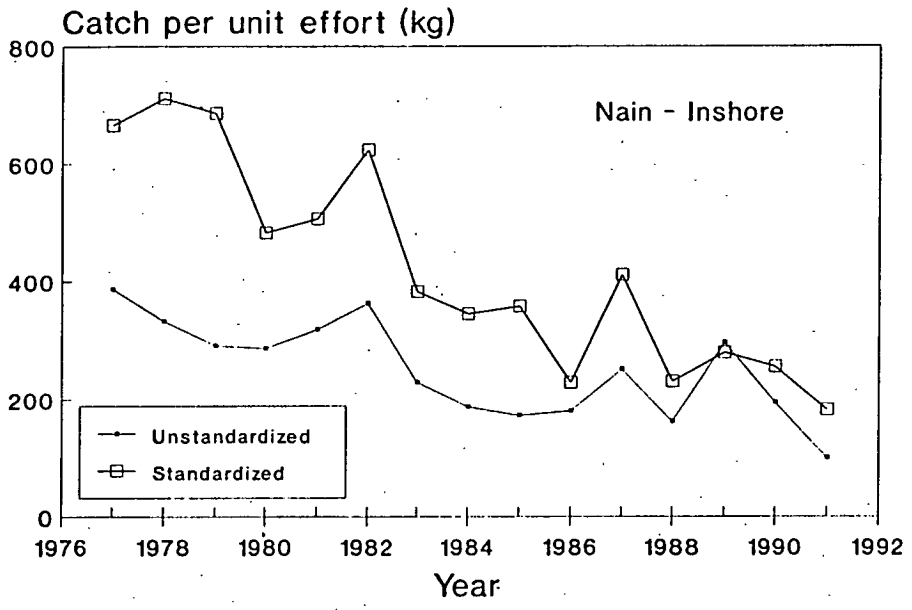
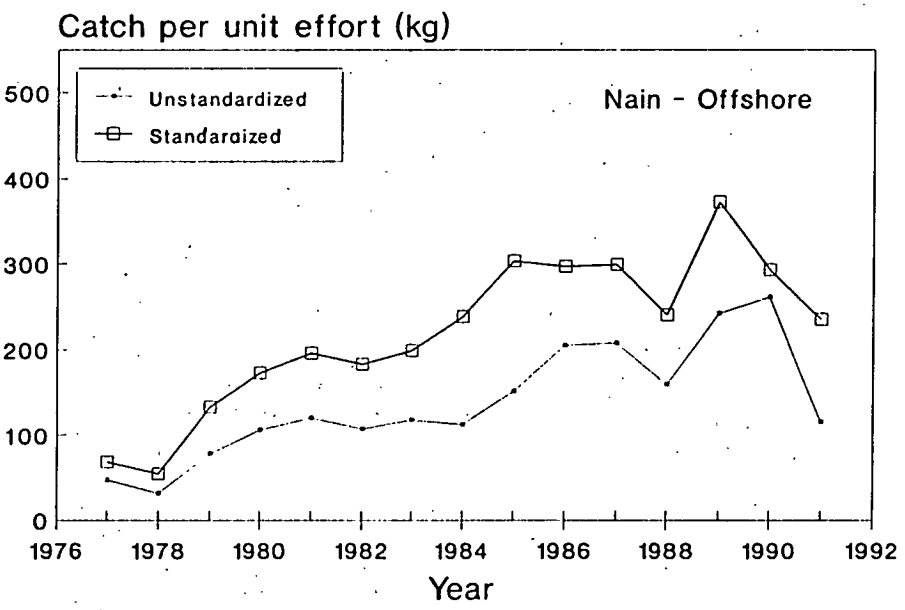


Fig. 4. Residual plots and influence diagnostics for the inshore catch rate series of the Nain stock unit, 1977-91.





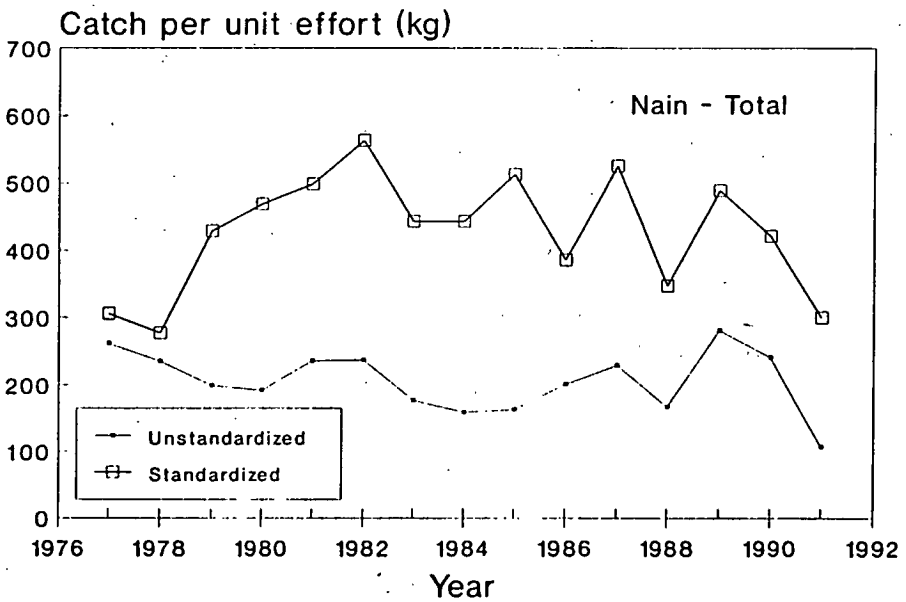
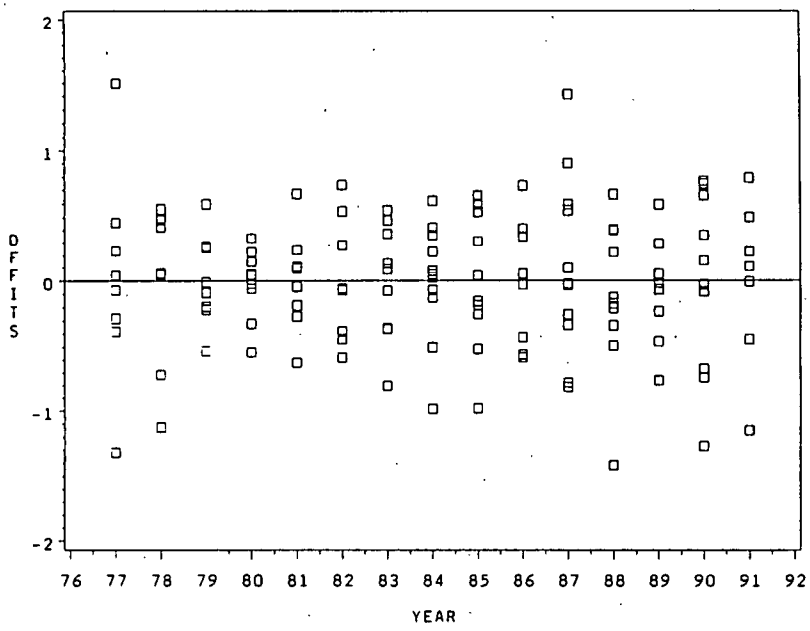
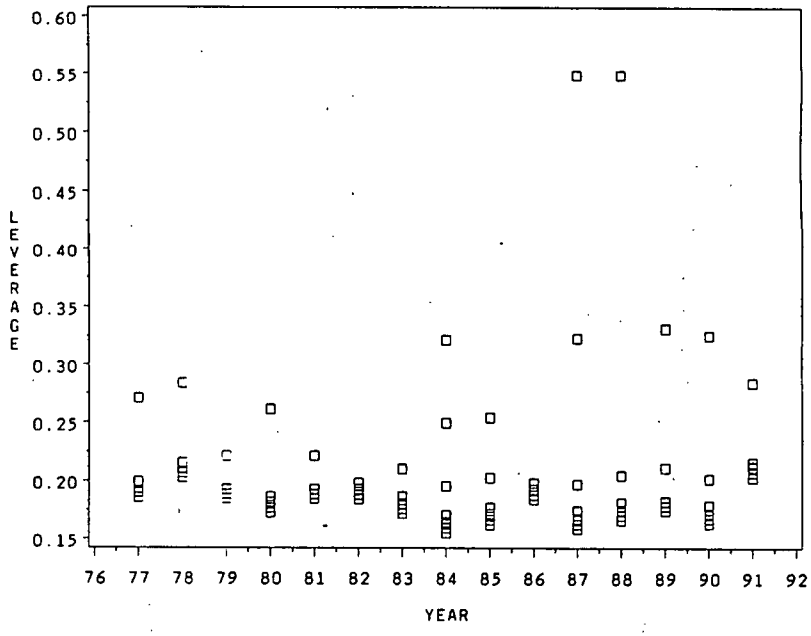
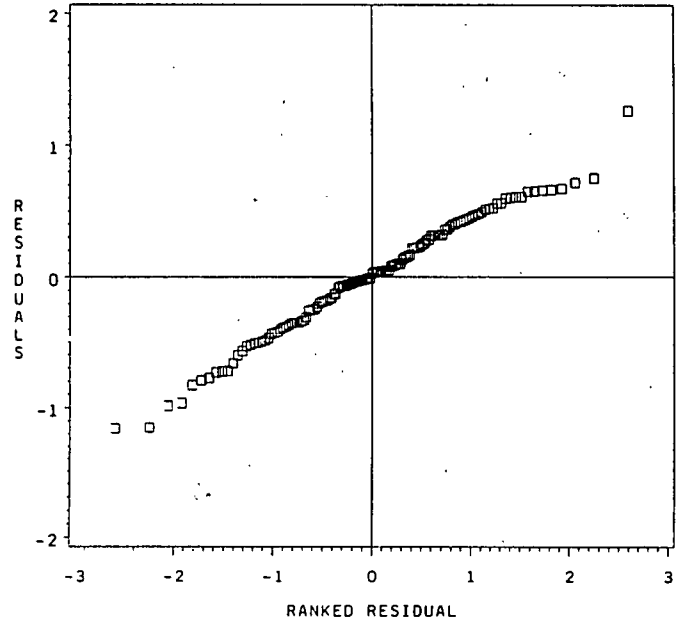


Fig. 5. Comparison of standardized and unstandardized catch rates for the Nain stock unit, 1977-91.







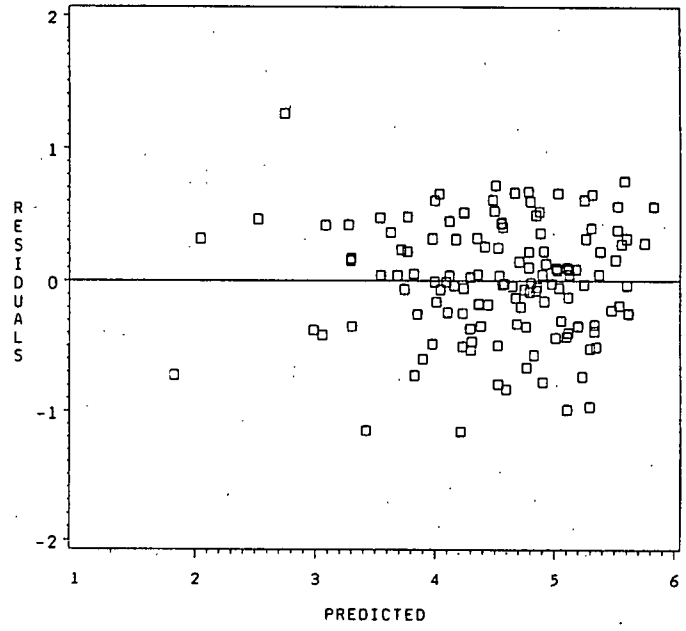
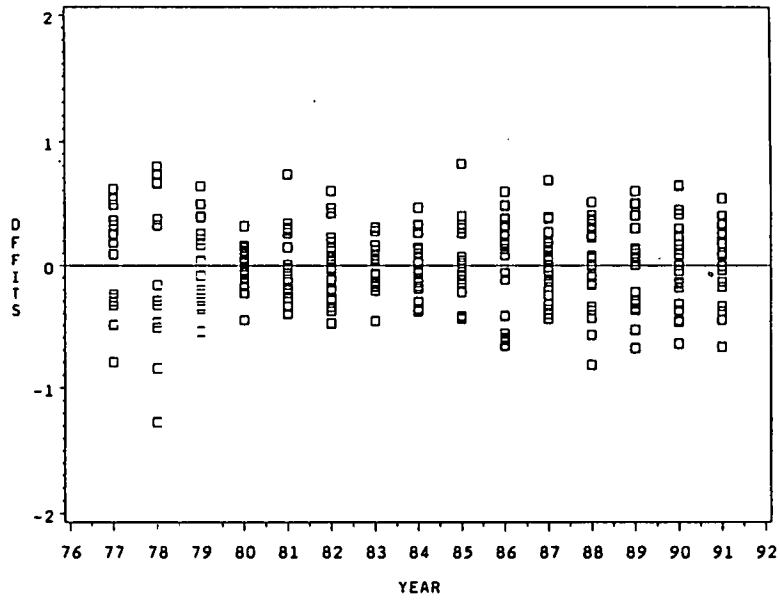
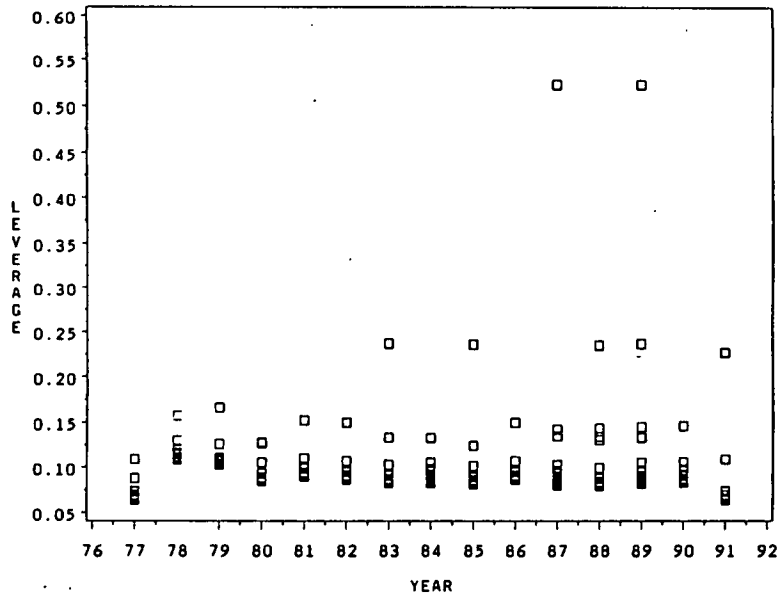
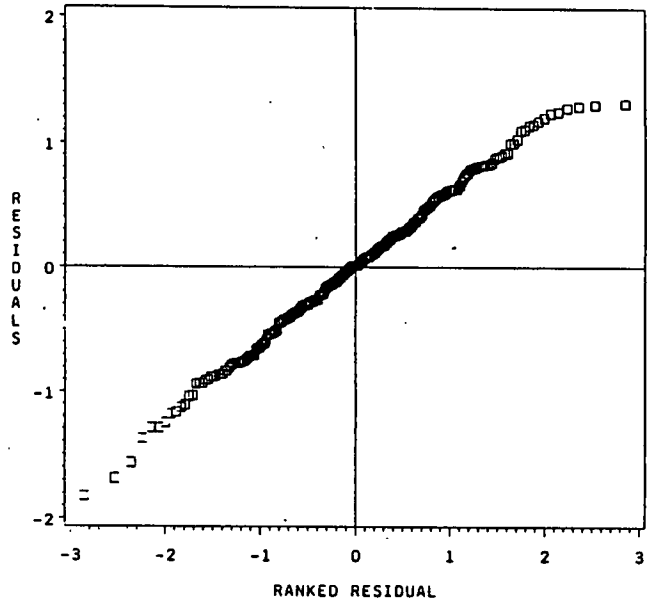


Fig. 6. Residual plots and influence diagnostics for the offshore catch rate series of the Nain stock unit, 1977-91.







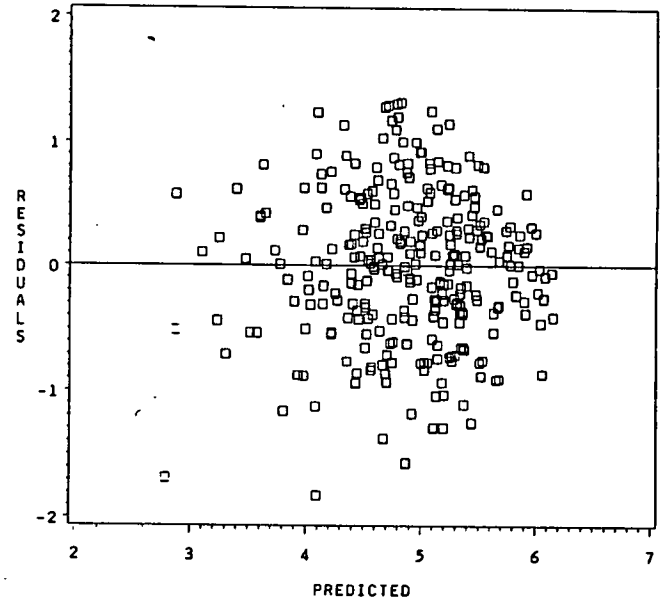
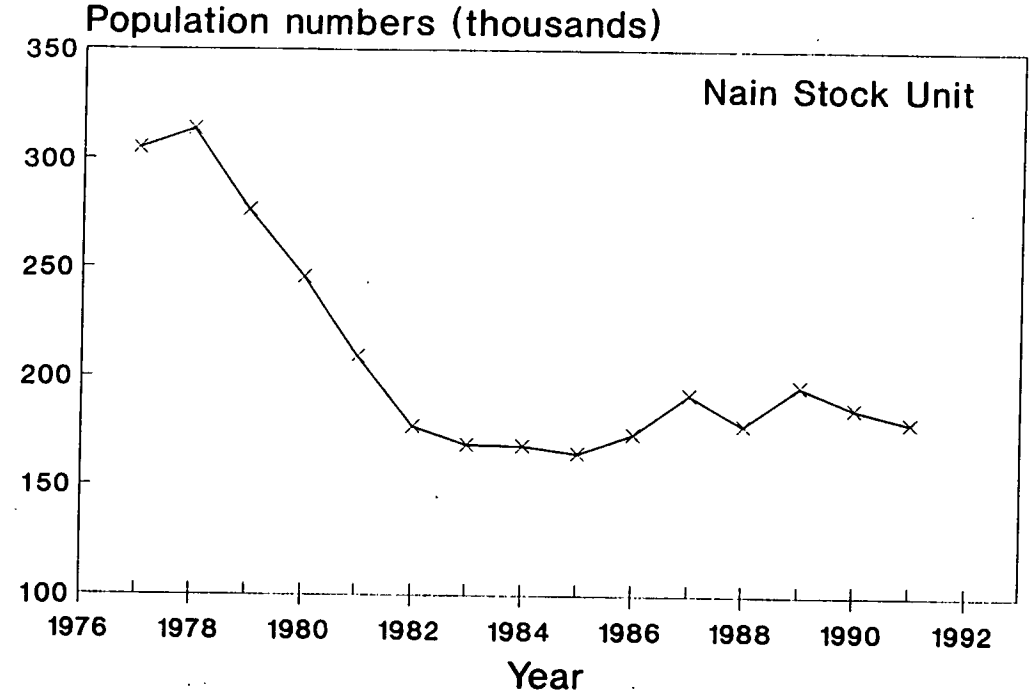


Fig. 7. Residual plots and influence diagnostics for the Nain stock unit (combined inshore and offshore zones) catch rate series, 1977-91.



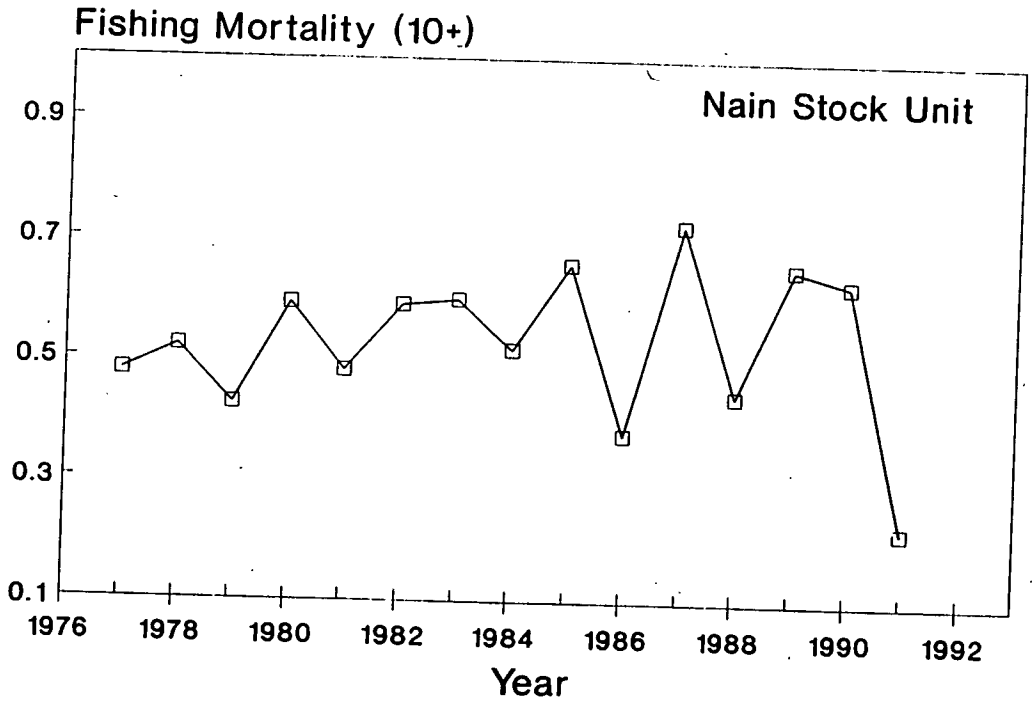


Fig. 8. Estimated population numbers and fishing mortality from the Nain stock unit Arctic charr population, 1977-91.

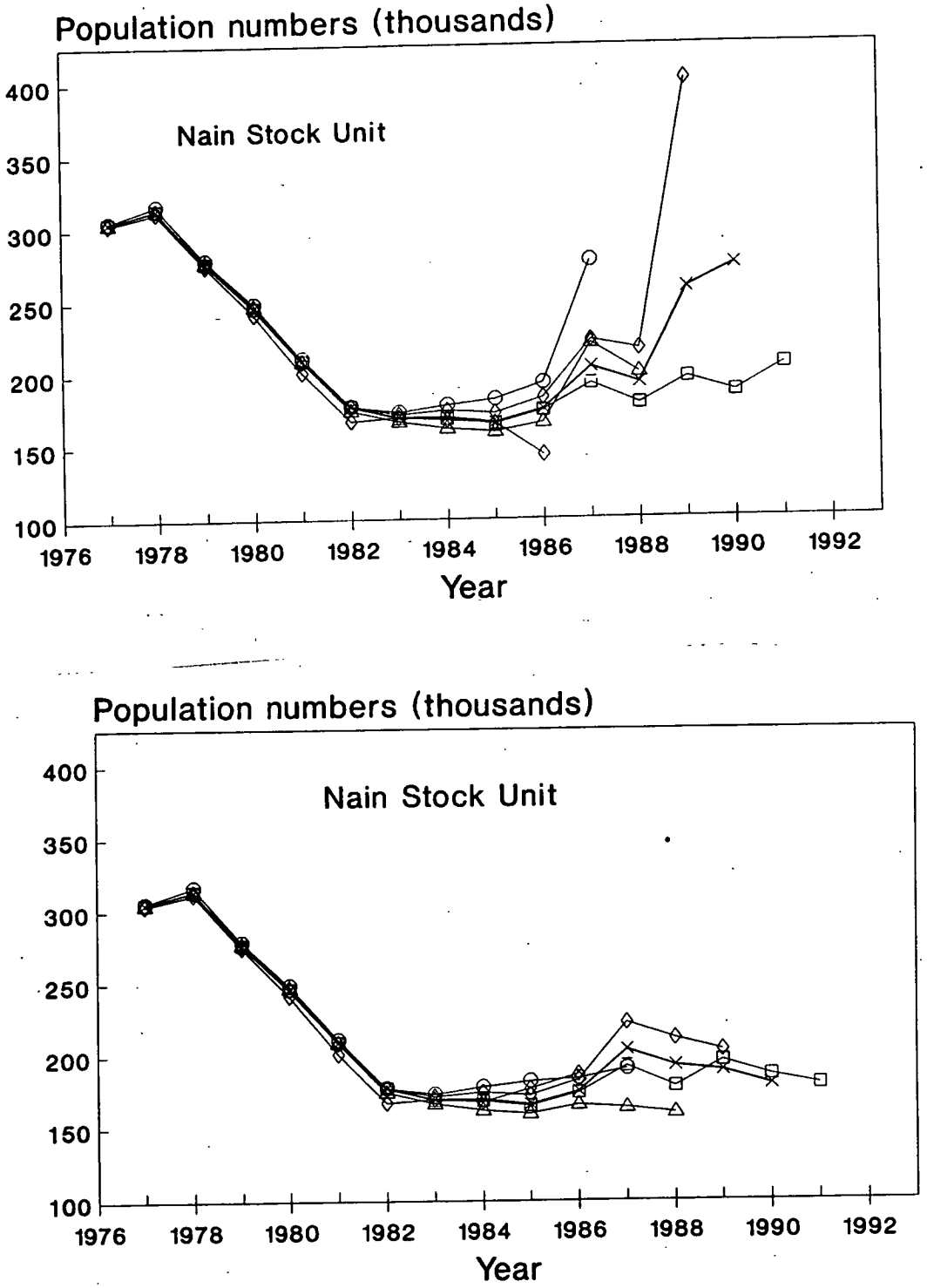


Fig. 9. Comparison of Nain stock unit population numbers as derived through retrospective ADAPT runs from 1977-86 to 1977-91. Lower figure illustrates population numbers when a correction for recruitment (mean) is used in the last two years.