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Assessment of the Nain Stock Unit Arctic charr population in 1989

by

J. B. Dempson
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

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Abstract

Reported landings of Arctic charr from the Nain assessment unit totaled 51 t in 1989, 9.5% higher than the total allowable catch for the unit and 34% higher than the catch in 1988. Total landings from the inshore zone were equal to the assigned quota of 30.5 t. Traditional interpretation of effort for the two zones indicated a decrease of 20% from 1988. A multiplicative analysis was used to try and derive a standardized catch rate series for the inshore and offshore fishing zones. The results indicated a significant interaction effect between classification variables year and zone and thus catch rates were not standardized. Calibration of sequential population analyses were attempted using unstandardized catch rate data as well as using information only from the inshore zone. While calibration results were difficult to interpret, they did suggest a terminal fishing mortality of about 0.4 in 1989. A projection for 1990 was not made but it is noted that estimates of average population biomass are higher during the past several years in comparison with estimates for the early to mid 1980's.

Résumé

Les débarquements déclarés d'omble chevalier provenant de l'unité d'évaluation de la baie Nain ont atteint 51 t en 1989. Elles ont donc été supérieures de 9,5 % au total des prises admissibles de l'unité et de 34 % aux prises de 1988. Les débarquements de la pêche côtière correspondaient au contingent alloué, soit 30,5 t. D'après les interprétations traditionnelles, l'effort dans les deux zones considérées a diminué de 20 % par rapport à 1988. On a eu recours à une analyse multiplicative pour tenter d'établir une série de taux de prises normalisés dans la pêche côtière et dans la pêche hauturière. Les résultats ont mis en évidence une importante interaction entre les variables de classification par année et par zone. Il a donc été impossible de normaliser les taux de prises. On a également tenté d'étalonner les analyses séquentielles de population à l'aide des taux de prises non normalisés et d'informations applicables uniquement à la zone de pêche côtière. Quoique difficiles à interpréter, les résultats de l'étalonnage dénotaient une mortalité par pêche de dernière année d'environ 4 % en 1989. Aucune projection n'a été effectuée pour 1990; on constate cependant que les estimations de la biomasse de population moyenne sont depuis ces dernières années supérieures à celles de la première moitié de la décennie 1980.

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 34 to 76 t (mean = 53 t, 1974-89) and from 1977 to 1989 have contributed 40% of the commercial production of charr from the Nain Fishing Region. In 1989, 61% of the commercial catch came from the Nain Stock unit. The recommended Total Allowable Catch (TAC) for 1988 was 47 t. No new advice was given for 1989 pending a further evaluation of the feasibility of standardizing inshore and offshore catch rates used in calibrating sequential population analyses. However, managers maintained the 1988 TAC for the 1989 season.

This paper summarizes information from the 1989 fishery and evaluates the results of the multiplicative analysis to standardize the catch rate series for the Nain stock unit.

2. Trends in catch and effort data - original series

Catch and effort data for the Nain stock unit are summarized in Table 1 for the period 1974-89. The highest catch of 76 t occurred in 1977, the lowest catch of 34 t was in 1975. The 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 applies to the entire stock unit.

Landings in 1989 totaled 51 t; 9.5% higher than the TAC for the entire unit and 34% higher than the catch in 1988. This was the highest catch since 1982. Effort, as interpreted in the traditional way, declined by 20% to the lowest value recorded for this unit. Catch per unit effort (CUE) increased by 68% from 1988 to the highest value recorded. Catch rates also increased by 83% and 52% for the inshore and offshore zones, respectively, in comparison with the previous year.

For the first time since 1985 more than 50% of the charr were caught in the inshore zone. Precautionary quotas and subsequent catches from inshore subareas were:

	Quota (t)	Catch (t)
Anaktalik Bay	5	1.2
Nain-Tikkoatokak Bay	16.5	23.4
Webb Bay	9.0	5.9
Total	30.5	30.5

While the quota was exceeded for the Nain-Tikkoatokak Bay subareas, the total quota assigned to the inshore zone was achieved. Many charr caught in the Nain-Tikkoatokak subarea were taken on the outer boundary of the designated inshore zone. At Black Island, 18 t of charr were caught; the most in this area since 1980. In general these data suggest that there was an overall higher abundance of charr available in 1989.

3. Size distribution of commercial landings

Figures 2, 3, and 4 illustrate the length-frequency distributions of commercial catches from the inshore and offshore zones, as well as combined, for the Nain stock unit. Since 1980, approximately 78,000 fish have been sampled from this unit to obtain information on the size composition of commercial landings. Modal size of fish caught has remained relatively constant since 1986, but as pointed out in past years, it has decreased over time. Charr 60 cm in fork length and over made up about 6% of the catch from 1980 through 1985; since 1986 this group has contributed to less than 2% of the catch.

4. Catch and average weights at age

Catch at age data are available since 1977 and are summarized in Table 2. These data have been revised somewhat from previous catch at age information. Previous estimates of total numbers caught were derived directly from commercial landings information using mean weight as estimated from purchase slip information (numbers of fish were recorded on some purchase slips). Data for some years were questionable and to avoid subjectively deciding which years were or were not appropriate, numbers at age were recalculated for years 1980 to present. This coincided with the time of increased sampling intensity in this fishery. Mean weight for each year was estimated from weight-length relationships (Table 3) using mean length as derived from length-frequency sampling. These mean weights were then divided into the total catch obtained from purchase slip information to obtain a revised estimate of total numbers of fish caught. On average for all years total numbers changed by less than 2% (up to 5% in two years).

Catch at age data, along with the estimated standard error and coefficient of variation for 1989 data, are summarized in Table 4. Those ages that contribute to the majority of the catch (ages 7 - 10, 82% of the total) appear to be estimated reasonably with the coefficient of variation 10% or less. The 1980 and 1981 year classes (year of hatching) represented by 8 and 9 year old fish in 1989 were the most abundant representing almost 56% of the catch (Table 2). Mean age of the catch in 1989 was 8.9 years and has ranged from 8.46 in 1977 to 9.83 years in 1982. A summary of the percent at age in the catch is provided in Table 5 and for comparison, the previous percent at age data is shown in Table 6.

Weights at age were derived from commercial samples obtained from 1977 to 1989. Gutted head-on weights were converted to whole weight using the conversion factor 1.22 (Dempson 1984). Weights at age have also been updated to coincide with the changes in numbers at age. Data are now provided by year rather than by groupings of three and four years (Table 7). A comparison of recorded total landings with the cross product total (sum of the matrix of estimated numbers x matrix of weights at age) agrees exceptionally well and differs by an average of less than 0.6% over the years 1980 to 1989. Mean lengths at ages 6, 7, 8, 10, and 12 are shown in Figure 5 with corresponding mean weights at these ages illustrated in Figure 6. Mean weights at age, particularly those of ages 9 through 12 have shown a decrease since the early 1980's (ages 9 and 11 not illustrated). Figure 7 illustrates the change in mean weight of a standard 50 cm fish (as derived from weight-length relationships), which has remained relatively constant (C.V. 3.7%) over time. No attempt was made to relate changes in size with population biomass or numbers.

5. Standardization of catch rates

A brief attempt was made last year at applying the multiplicative model to derive a standardized catch rate series for the Nain stock unit, using information on catch rates from both inshore and offshore zones. As illustrated in Figure 8, inshore and offshore rates differ for most years and do not necessarily trend in the same direction except for the past four or five years. Dissimilar trends in the catch rate series is suggestive of an interaction effect and may violate an assumption of the multiplicative model.

Results of an analysis of variance of log transformed catch rate on classification variables zone, week, and year, with a year-zone interaction term are summarized in Table 8. The model explained 56% of the variation. Significant differences occurred between all classification variables including the interaction between year and zone. Owing to the presence of an interaction effect, catch rates between inshore and offshore zones were not standardized.

6. Estimation of stock size - calibration of SPA

Commercial catch rate information was analyzed in a variety of ways in an attempt to calibrate the sequential population analyses and determine an appropriate value of fishing mortality in 1989. The indices used can be summarized as follows:

1 - Commercial inshore catch rate aggregated for ages 10-17 - intercept model

2 - Commercial total unit catch rate aggregated for ages 10-17 - intercept model

3 - Commercial inshore catch rate aggregated for ages 10-17 - zero intercept model

4 - Commercial total unit catch rate aggregated for ages 10-17 - zero intercept model

5 - Commercial inshore or total catch rate ages 10-13 disaggregated - intercept model

6 - Commercial inshore or total catch rate ages 10-13 disaggregated - zero intercept model

Initially, SPA was run using partial recruitment (PR) values from last year at a terminal fishing mortality (F_t) of 0.4. An iterative procedure was used to obtain estimates of fishing mortality for the oldest age group (Rivard 1982). Following this, partial recruitment rates were then calculated using the historical averaging method from the matrix of fishing mortalities generated by SPA using years 1983-87. These values were then applied to the terminal F of 0.4 and the procedure repeated until the PR values stabilized at:

Age	6	7	8	9	10
PR	0.01	0.168	0.452	0.722	1.0

A series of SPAs were run using a range of terminal fishing mortality rates from 0.3 to 0.6. In each run, fishing mortality rates for the oldest age group were re-evaluated using the iterative procedure. The calibration procedure examined regressions of mean population biomass on various catch rate indices (identified above), examining at which F_t the R-square was maximized while reducing the residual sum of squares for the last three years as well as the minimizing the residual for 1989.

6.1 Commercial inshore catch rate aggregated for ages 10-17 - intercept model

With data for all years included, regressions were not statistically significant. With 1987 omitted (as in past years) only at $F_t = 0.4$ was there a statistically significant relationship. Dropping both 1985 and 1987 improved the relationships which then had the highest correlation at $F_t = 0.4$ ($R^2 = 0.42$, $P = 0.030$). The residual for the last year (1989) was lowest between $F_t = 0.3$ and 0.4 (no run done at $F_t = 0.35$) while the same was true for the sum of squares of residuals for the last three years. Intercepts were significant in all cases where F_t was less than 0.6, and thus were decreasing as F_t increased.

6.2 Commercial total unit catch rate aggregated for ages 10-17 - intercept model

Regressions using catch rates based on the effort series for the total stock unit were generally much better than those using inshore data only. With data for all years included in this set of regressions, the highest correlation occurred at $F_t = 0.4$ ($R^2 = 0.409$, $P = 0.018$). The residual for the last year (1989) was lowest when F_t was between 0.3 and 0.4 while again the same was observed for the sum of squares of residuals for the last three years. As above, intercepts were significant when F_t was less than 0.5. With 1987 dropped, essentially the same pattern was observed although relationships were improved ($R^2 = 0.48$ at $F_t = 0.4$). Similarly with both 1985 and 1987 dropped R^2 improved to 0.55 at $F_t = 0.4$. Figure 9 illustrates relationships with 1987 dropped for terminal fishing mortalities of 0.3, 0.4 and 0.5. As observed in the illustration, there is a trend in residuals with values from 1982 onwards less than those predicted.

6.3 Commercial inshore catch rate aggregated for ages 10-17 - zero intercept model

Even though intercepts were significant, regressions were also run with a zero intercept model to compare with results from above. As this procedure forces the line through the origin, R^2 values are all high (highest at F_t = 0.3), but residuals, either for 1989 or the sum of squares of residuals for the last three years were minimized when F_t = 0.4. With data for 1987 omitted from the analysis, results were the same for residual comparisons although the R^2 was maximized when F_t was also equal to 0.4. A plot of these relationships with F_t ranging from 0.3 to 0.5 is shown in Fig. 10 (all years included).

6.4 Commercial total unit catch rate aggregated for ages 10-17 - zero intercept model

Again R^2 values were higher using the catch rate series for the total stock unit and were maximized when F_t = 0.4 with or without 1987 included in the relationship. Residuals were minimized when F_t was between 0.3 and 0.4 and the trend in residuals was improved over those relationships discussed above.

6.5 Commercial inshore or total unit catch rate ages 10-13 disaggregated - intercept model

Following the attempts using age aggregated data, age disaggregated relationships were explored beginning at age 13 and progressing back to the younger ages.

At age 13 relationships were not statistically significant. At age 12, relationships were not significant using the inshore catch rate data and only when F_t was equal to or greater than 0.4 using the total unit catch rate information. Deleting 1985 from the analyses using inshore data yielded significant relationships with the highest R^2 at F_t = 0.5 and with the residuals minimized when F_t = 0.4. The same results were obtained using the total unit catch rate information but R^2 values were much higher using the total unit catch rate data (R^2 = 0.34 vs 0.54 at F_t = 0.5). Intercepts were statistically significant at all F_t's and there was no indication of a trend in residuals.

At age 11, F_t = 0.4 maximized the R^2 values and minimized residuals for both inshore or total catch rate series. R^2 values were again higher for the total catch rate data (R^2 = 0.68 vs 0.39 for inshore). Intercepts were significant up to F_t = 0.4 and again there were trends in the residuals with recent years.

At age 10, the highest R^2 values occurred at F_t = 0.3 with the inshore catch rate series and at 0.4 for the total unit data. Residuals were minimized at F_t = 0.3 for both sets of data. Intercepts were significant up to F_t = 0.4 for the inshore data, but only up to 0.3 for the total unit. Trends in residuals were evident as above with recent years data less than that predicted by the relationships.

6.6 Commercial inshore or total catch rate ages 10-13 disaggregated - zero intercept model

Similar to the earlier attempts at calibration using age aggregated data, regressions were also run with a zero intercept model to compare with results from above even though in most cases intercepts were significant at least up to about F_t = 0.4 or 0.5.

Beginning at age 13 (1987 data omitted as above), R^2 was maximized and residuals minimized when F_t = 0.4 for both sets of catch rate data. Figure 11 illustrates the relationship over terminal fishing mortalities of 0.3 to 0.5 using the inshore catch rate data. Note that forcing the line through the origin removes much of the trend in residuals over time that was evident using an intercept model.

Fishing mortality on age 13 and older age fish was then set to 0.4 and a series of SPAs were run to calibrate age 12. The highest R^2 values were obtained when F_t = 0.4 using either inshore or total unit catch rate information. Residuals were minimized at F_t = 0.55 for the inshore data or at 0.5 using the total catch rate series. A plot of the relationship for age 12 using the inshore information is illustrated in Fig. 12. Subjectively, a terminal F of 0.5 was then applied to age 12 fish and another series of SPAs were run to calibrate age 11. Note at each new set of runs, partial recruitment information was re-evaluated and updated if necessary.

At age 11, the highest R^2 values resulted with F_t = 0.35 (for both sets of catch rate data). Residuals were minimized at F_t = 0.4 using the inshore data and at 0.35 for the total unit catch rate information. Figure 13 illustrates the relationship with F_t varying from 0.3 to 0.5. Note here, however, there again is a trend in residuals. With the R^2 and residual information suggesting a value between 0.35 and 0.4, a terminal F of 0.37 was applied to age 11 and another set of SPA runs were carried out to calibrate age 10.

At age 10, R^2 was maximized at F_t = 0.35 using the inshore catch rate data and at 0.3 for the total unit series. Residuals were minimized at F_t = 0.4 with the inshore data and at 0.35 for the total unit data. Figure 14 shows the relationships again using the inshore catch rate series with F_t ranging from 0.3 to 0.5. Trends in residuals are present moreso with the inshore catch rate series than with the total unit series. Averaging the results at age 10 could indicate F_t at around 0.36.

The above attempts at calibration to derive an estimate of terminal fishing mortality in 1989 are difficult to interpret. Some of the relationships are characteristized with trends in residuals and marginal significance although in total they suggest a terminal fishing mortality rate of about 0.4. While a specific terminal fishing mortality could not be clearly determined for 1989, it is noted that, estimates of average population biomass are higher during the past several years in comparison with estimates for the earlier to mid 1980's even with a terminal fishing mortality rate of 0.6.

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Table 1. Summary of catch and effort statistics for the Nain assessment unit, 1974-89. 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	

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

Table 2. Estimated catch at age of Arctic charr from the Nain stock unit, 1977 - 1989.

CATCH AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
6	2003	371	430	75	145	83	470	182	103	210	483	204	903
7	9250	6703	4306	960	2118	977	2791	2612	2463	4129	5462	6288	4750
8	12453	13122	11568	10519	6877	4782	5842	4619	6506	7713	6293	7166	9707
9	7630	7984	9593	16342	15435	7255	6996	5671	4722	5862	7548	4688	8464
10	5052	4406	4208	8345	9787	7987	4177	4374	4111	2857	4498	3607	3785
11	2454	2367	2168	4077	3746	4936	4357	2173	2494	1284	2013	1631	2853
12	988	1688	1573	1340	991	2976	2762	1495	1605	625	1375	650	1234
13	358	312	418	813	304	561	600	738	901	240	898	324	665
14	180	272	312	522	151	451	557	281	534	199	306	136	277
15	1	118	34	43	42	59	70	96	322	205	357	52	28
16	1	97	14	1	13	46	27	57	93	50	180	20	6
17	1	1	1	66	10	23	95	89	21	42	37	40	1
6+	40371	37441	34625	43103	39619	30136	28744	22387	23875	23416	29450	24806	32673
7+	38368	37070	34195	43028	39474	30053	28274	22205	23772	23206	28967	24602	31770

Table 3. Summary of slope and intercept parameters from log - log weight length relationship for Artic 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

Table 4. Summary of catch-at-age data for the Nain stock unit in 1989, with standard error and co-efficient of variation (C.V.).

Age	Catch at age	Standard Error	C.V. (%)
6	903	172.6	19.1
7	4750	436.7	9.2
8	9707	563.6	5.8
9	8464	542.4	6.4
10	3785	378.7	10.0
11	2853	351.0	12.3
12	1234	229.7	18.6
13	665	170.3	25.6
14	277	111.3	40.2
15	28	28.3	101.0
16	6	6.1	101.3

Table 5. Summary of the revised percent at age in the commercial catch of Arctic charr from the Nain stock unit, 1977-1989.

SUMMARY OF PERCENT AT AGE FOR THE NAIN STOCK UNIT

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
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	2.8
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	14.5
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	29.7
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	25.9
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
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	8.7
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	3.8
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	2.0
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	0.8
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	0.1
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	0.0
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	0.0

Table 6. Summary of percent at age in the catch of Arctic charr from the Nain stock unit, 1977 - 1988; information as used last year.

PERCENT AT AGE

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	5.0	1.0	1.2	0.3	0.4	0.5	0.7	0.4	0.7	0.9	1.6	0.8
7	22.9	17.9	12.4	2.3	4.1	2.1	5.9	9.4	12.2	17.7	18.5	25.3
8	30.8	35.0	33.4	27.1	17.5	14.8	16.7	18.0	30.9	33.0	21.3	28.9
9	18.9	21.3	27.7	38.0	40.4	25.9	23.5	26.6	19.2	25.1	25.6	18.9
10	12.5	11.8	12.2	19.4	26.0	28.8	18.8	23.8	15.7	12.2	15.2	14.5
11	6.1	6.3	6.3	8.1	8.7	16.8	18.4	11.1	9.1	5.5	6.8	6.6
12	2.4	4.5	4.5	2.2	1.8	8.7	11.8	7.2	5.6	2.7	4.7	2.6
13	0.9	0.8	1.2	1.7	0.6	1.4	3.0	2.7	3.5	1.0	3.0	1.3
14	0.4	0.7	0.9	0.8	0.2	0.9	1.1	0.7	1.9	0.8	1.0	0.5
15	0.0	0.3	0.1	0.1	0.2	0.2	0.0	0.1	0.9	0.9	1.2	0.2
16	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.6	0.1
17	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.0	0.3	0.2

Table 7. Summary of weight at age (kg-round) data for Arctic charr from the Nain stock unit, 1977 - 1989.

AVERAGE WEIGHT AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
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	1.16
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	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	1.56
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	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	1.71
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	1.68
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	1.64
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	1.69
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	1.74
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	1.97
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	2.56
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	1.64

Table 8. Results of an analysis of variance of log transformed catch rate on classification variables zone, week, and year with a year - zone interaction.

DEPENDENT VARIABLE: LOGCUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	38	88.09718891	2.31834708	7.06	0.0001	0.557536	11.4670
ERROR	213	69.91457106	0.32823742		ROOT MSE		LOGCUE MEAN
CORRECTED TOTAL	251	158.01175997			0.57292008		4.99624623

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
ZONE	1	30.15621707	91.87	0.0001	1	38.82723095	118.29	0.0001
WEEK	13	28.66780751	6.72	0.0001	13	27.79150419	6.51	0.0001
YEAR	12	8.82084089	2.24	0.0111	12	10.11235718	2.57	0.0034
YEAR*ZONE	12	20.45232343	5.19	0.0001	12	20.45232343	5.19	0.0001

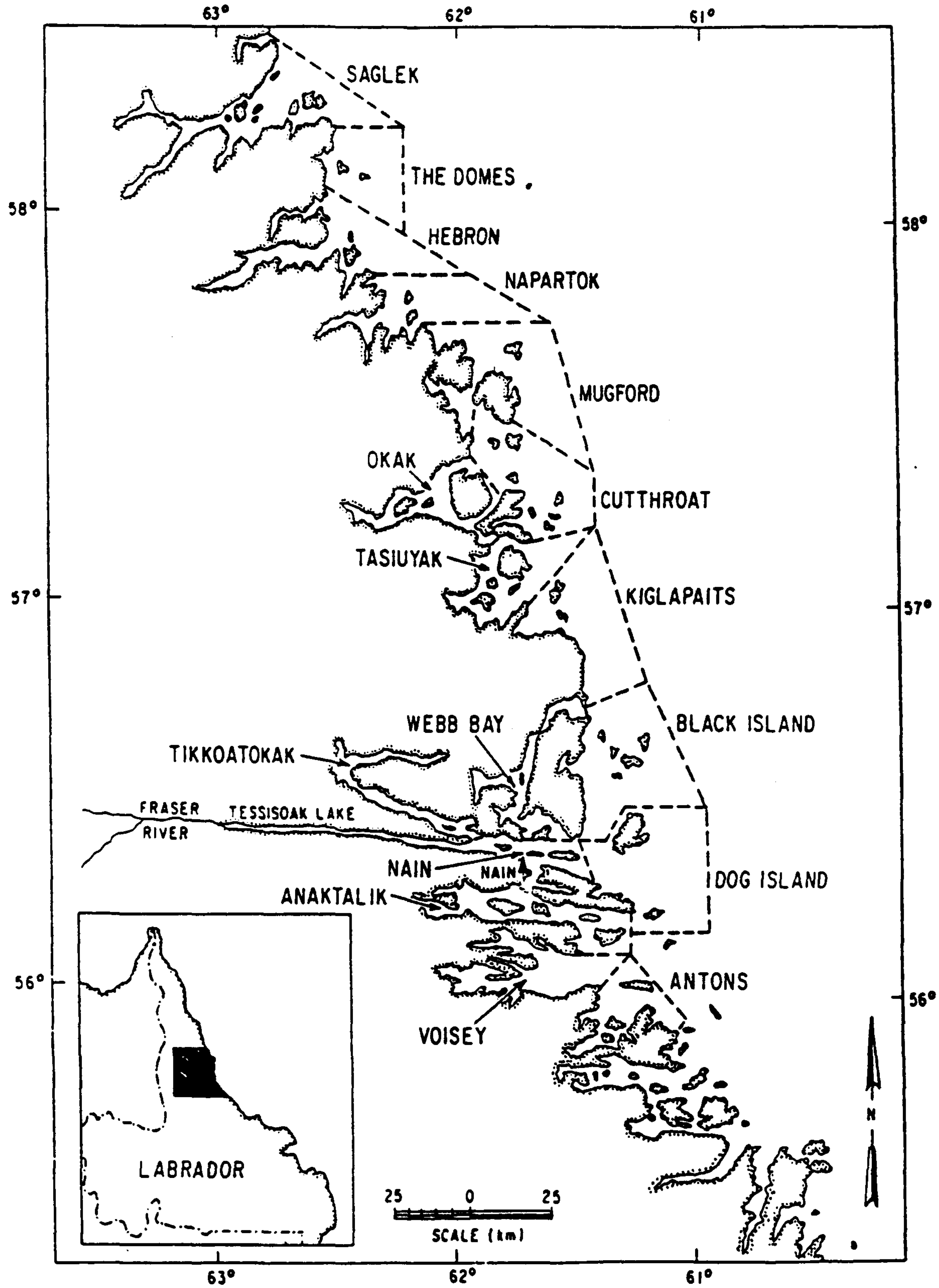

Figure 1. Geographical separation of the Nain Fishing Region subareas.

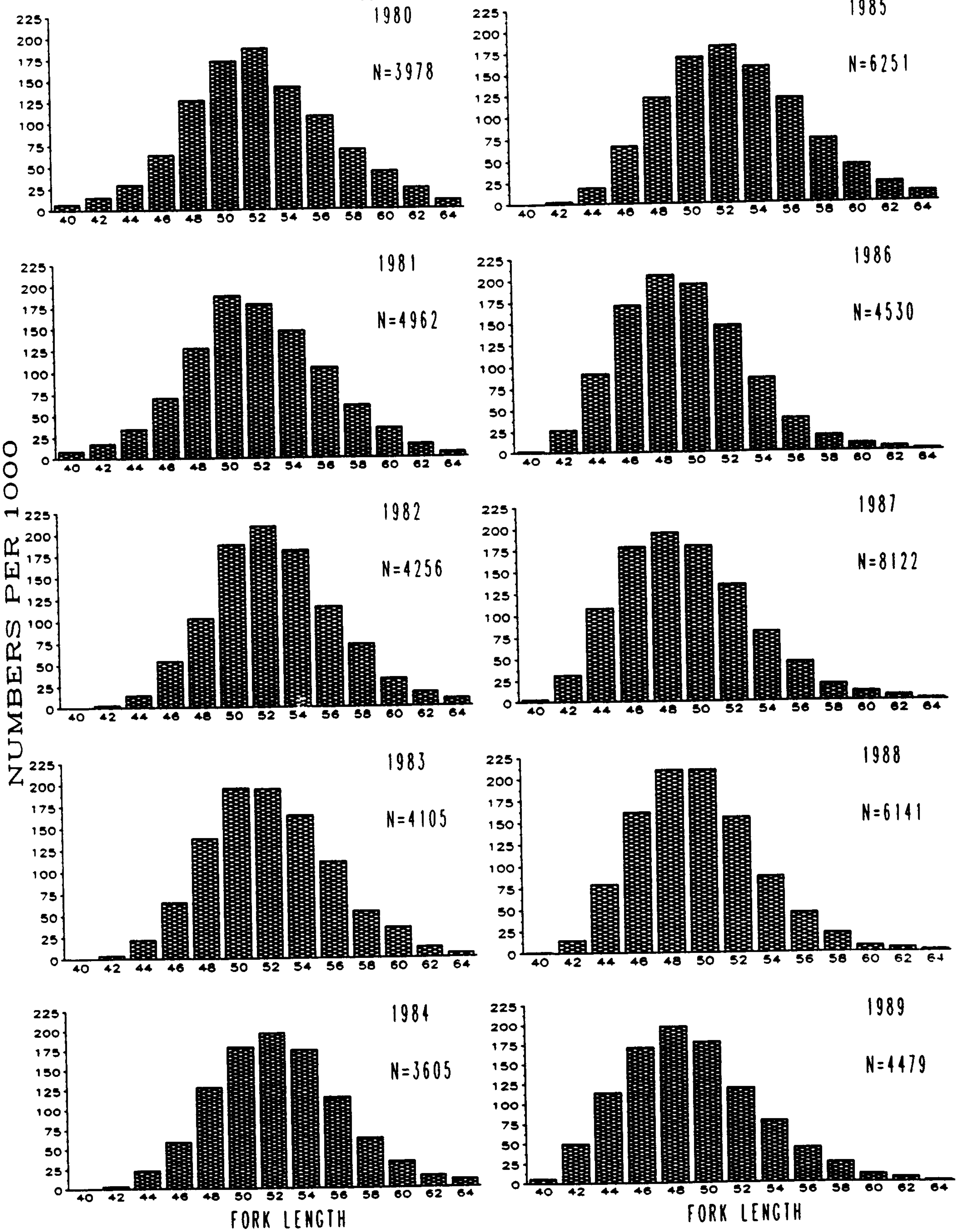

Fig. 2. Length-frequency distributions of Arctic charr catches from the inshore zone of the Nain stock unit, 1980 - 1989.

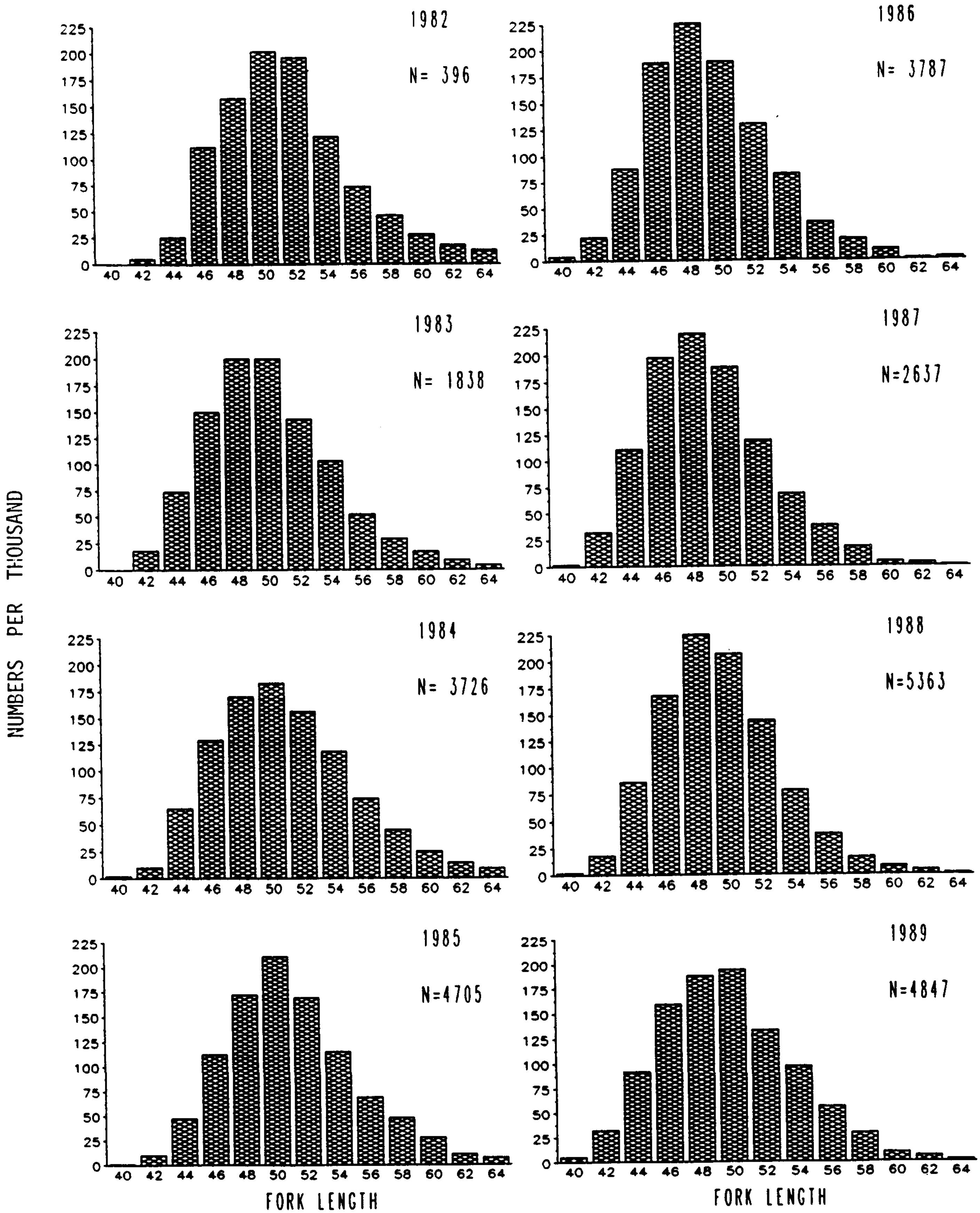

Fig. 3. Length-frequency distributions of Arctic charr catches from the offshore zone of the Nain stock unit, 1982 - 1989.

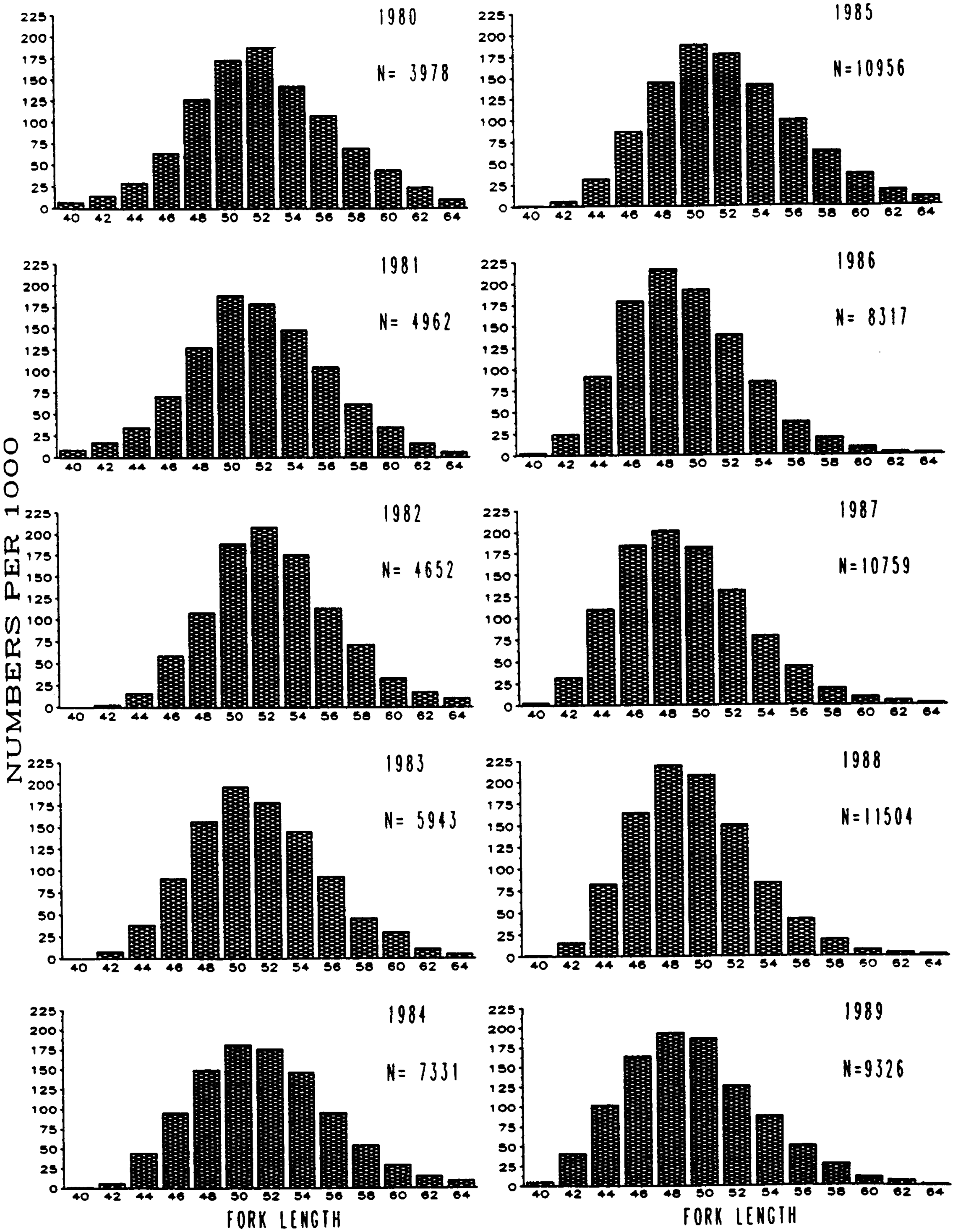

Fig. 4. Length-frequency distributions of the Arctic charr catch from the Nain stock unit (inshore and offshore zones combined), 1980 - 1989.

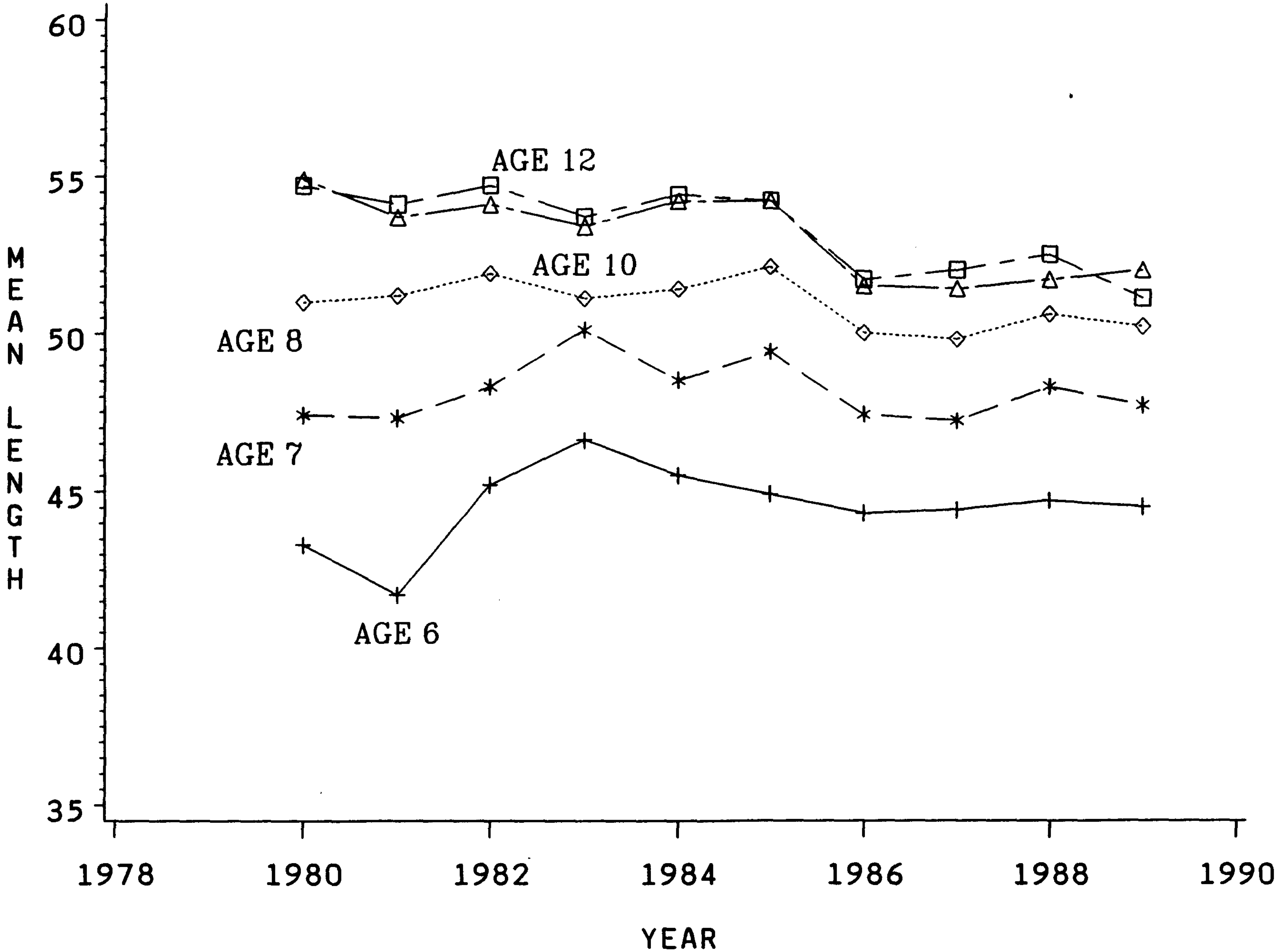

FIG. 5 MEAN LENGTH AT AGES 6, 7, 8, 10, AND 12, BY YEAR FOR THE NAIN REGION STOCK UNIT 1980–1989

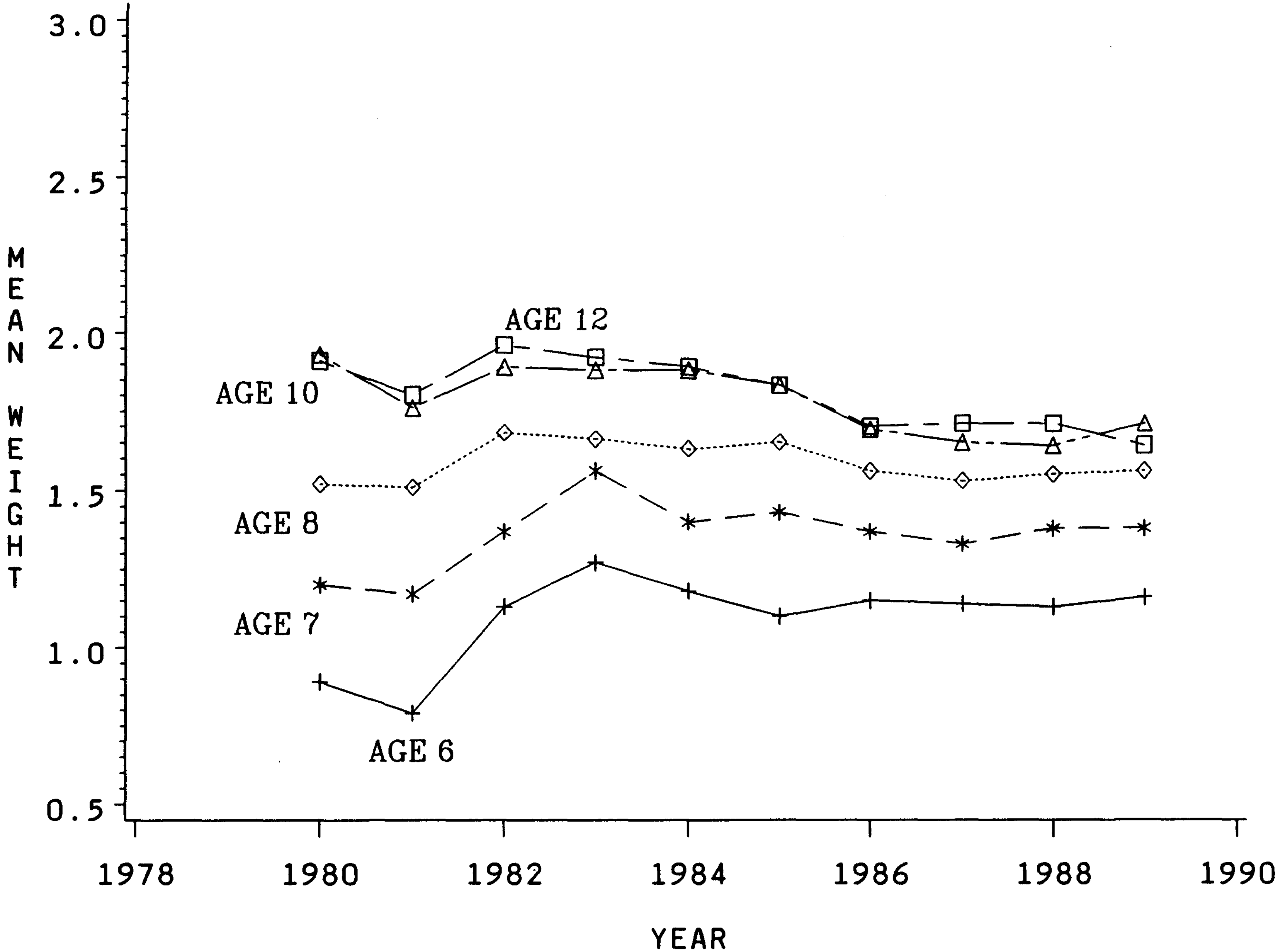

FIG. 6 MEAN WEIGHT AT AGES 6, 7, 8, 10, AND 12, BY YEAR FOR THE NAIN REGION STOCK UNIT 1980–1989

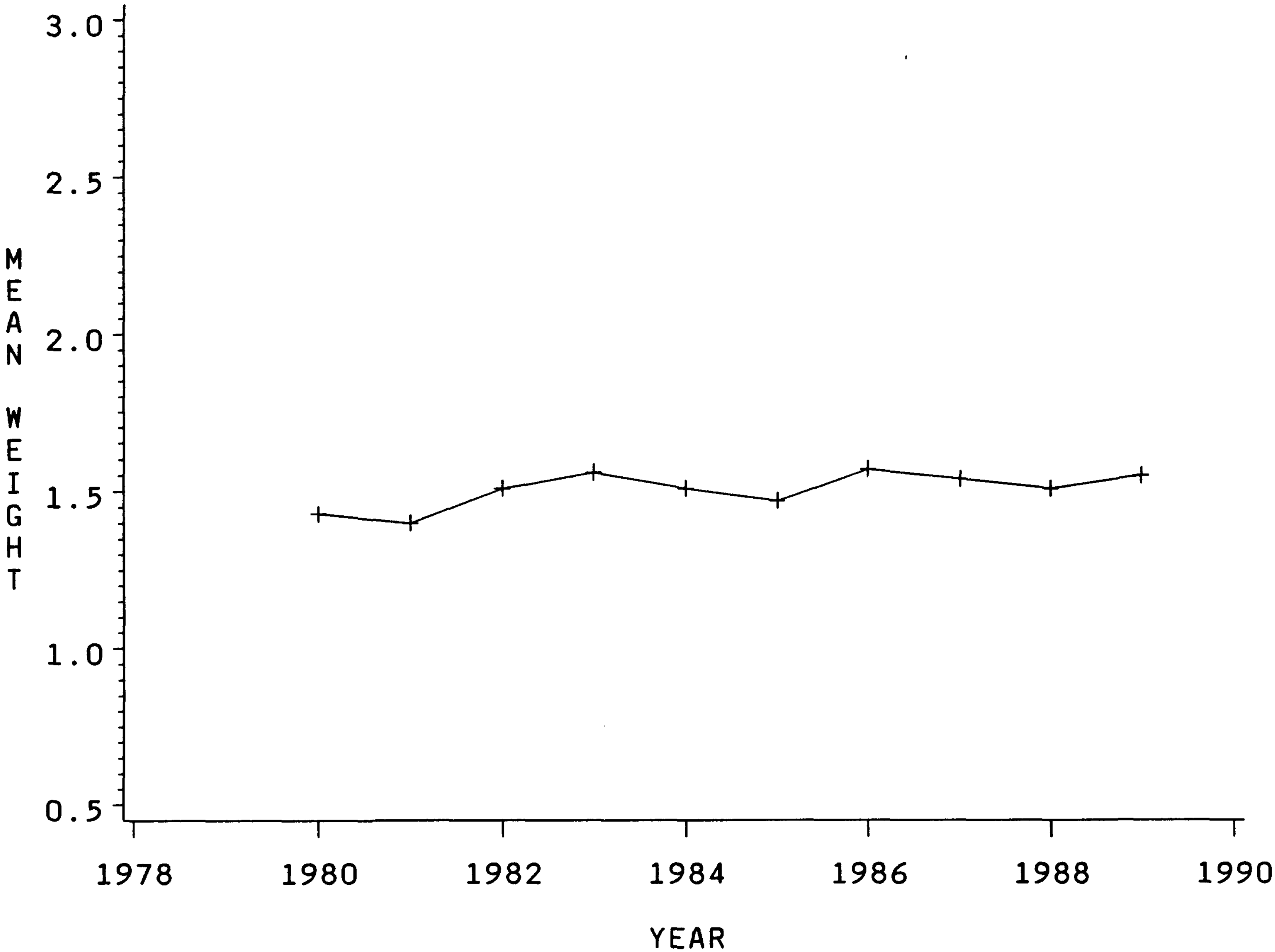

FIG. 7 MEAN WEIGHT OF A 50 CM ARCTIC CHARR FROM THE NAIN REGION STOCK UNIT 1980–1989

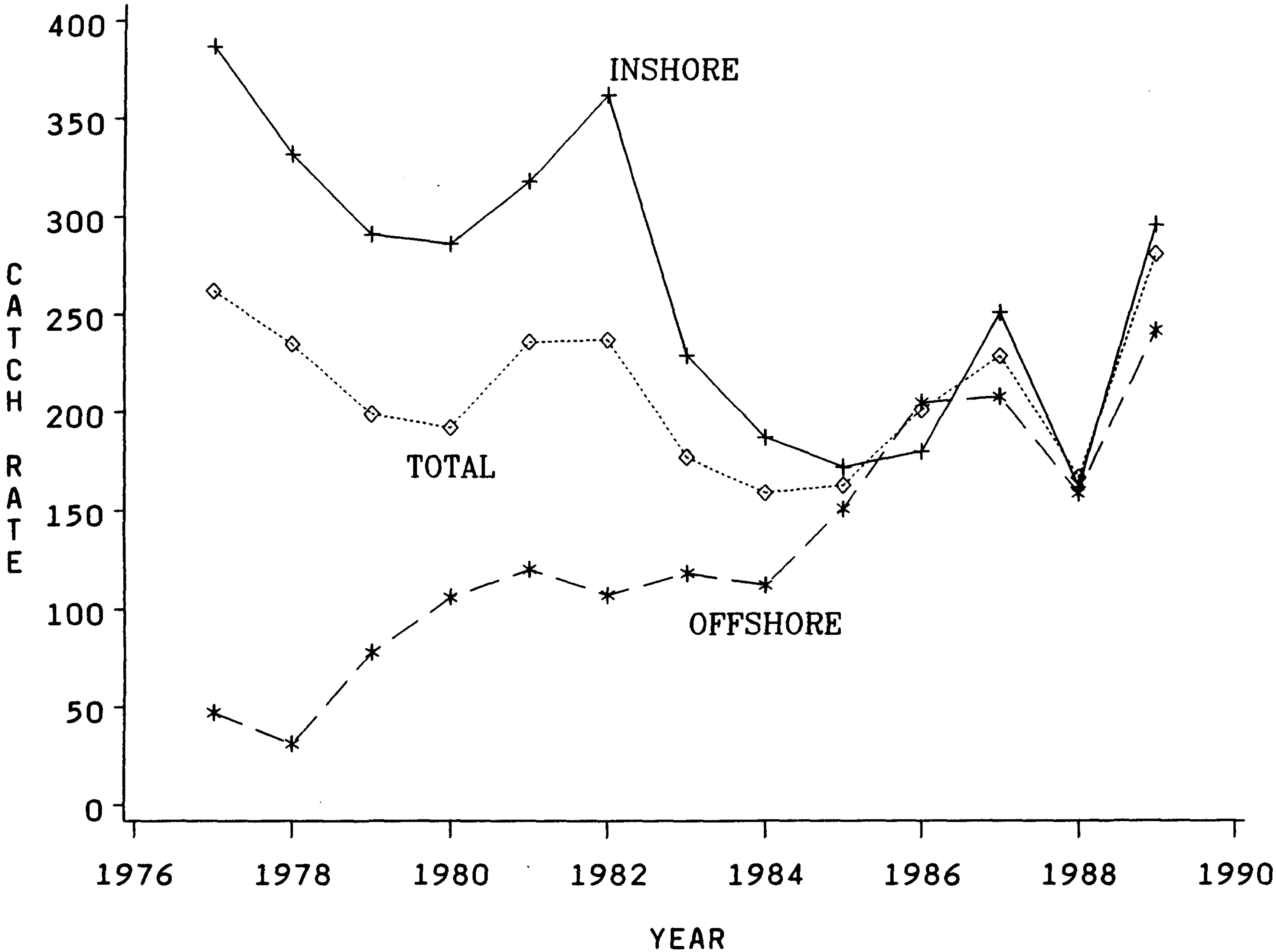

FIG. 8 SUMMARY OF NAIN REGION ARCTIC CHARR INSHORE, OFFSHORE AND TOTAL UNIT CATCH RATES, 1977–1989

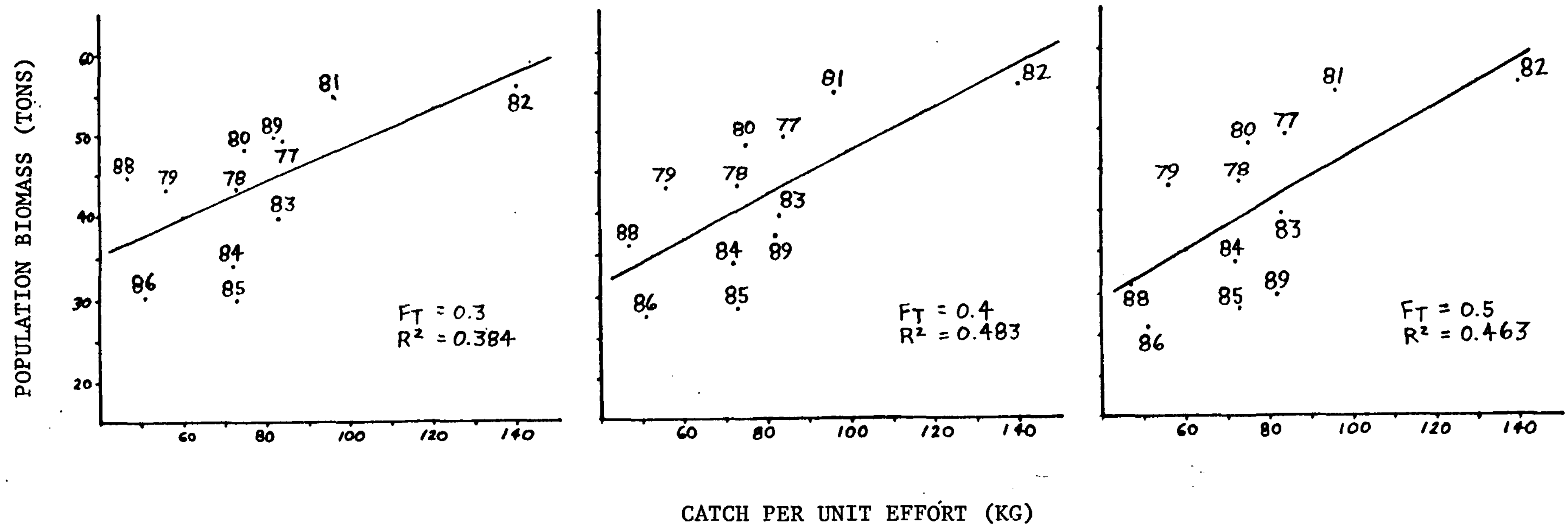

Fig. 9. Regressions of estimated average population biomass of fully recruited fish on catch per unit of effort (total unit) for the Nain stock unit with varying rates of terminal fishing mortality. Data for 1987 are not included in the relationships.

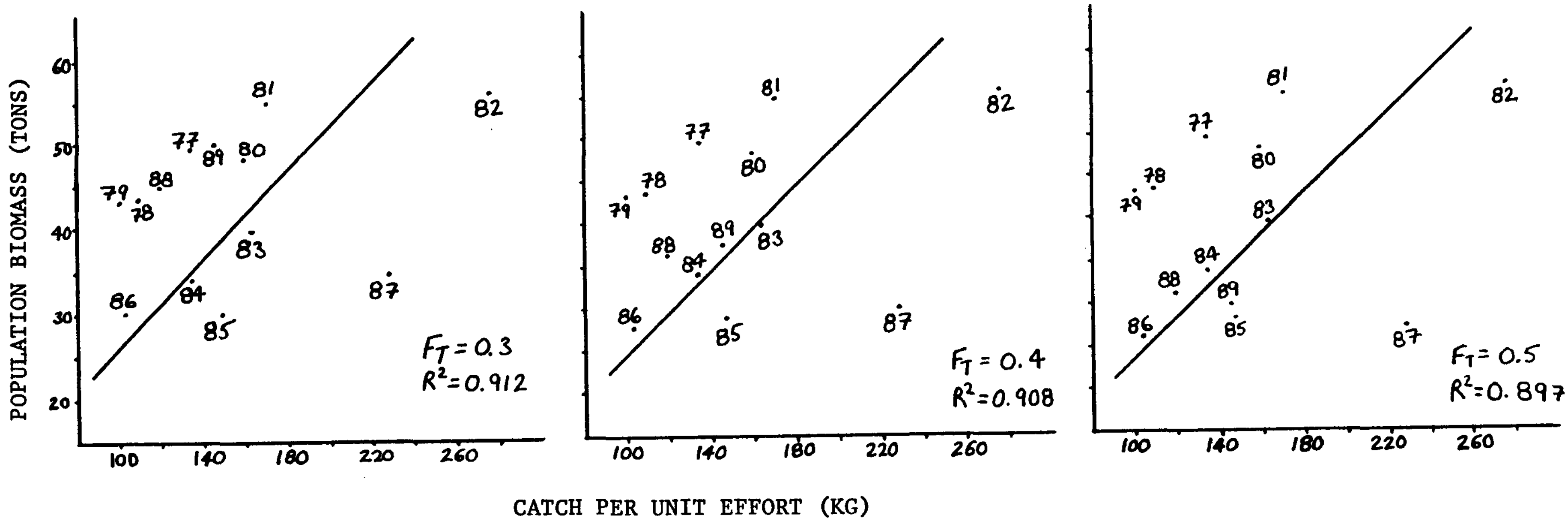

Fig. 10. Regressions of estimated average population biomass of fully recruited fish (age 10 - 17) on catch per unit effort (inshore catch rate) using a zero intercept model for the Nain stock unit.

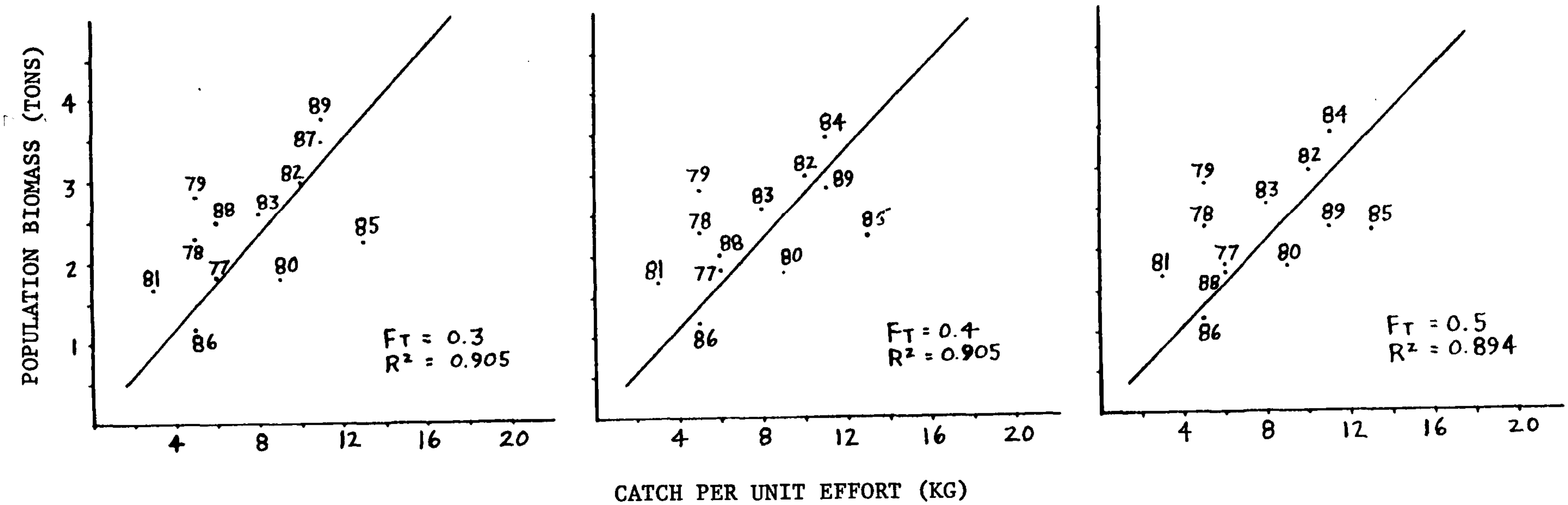

Fig. 11. Regressions of estimated average population biomass of age 13 fish on catch rate(inshore) with a zero intercept model.

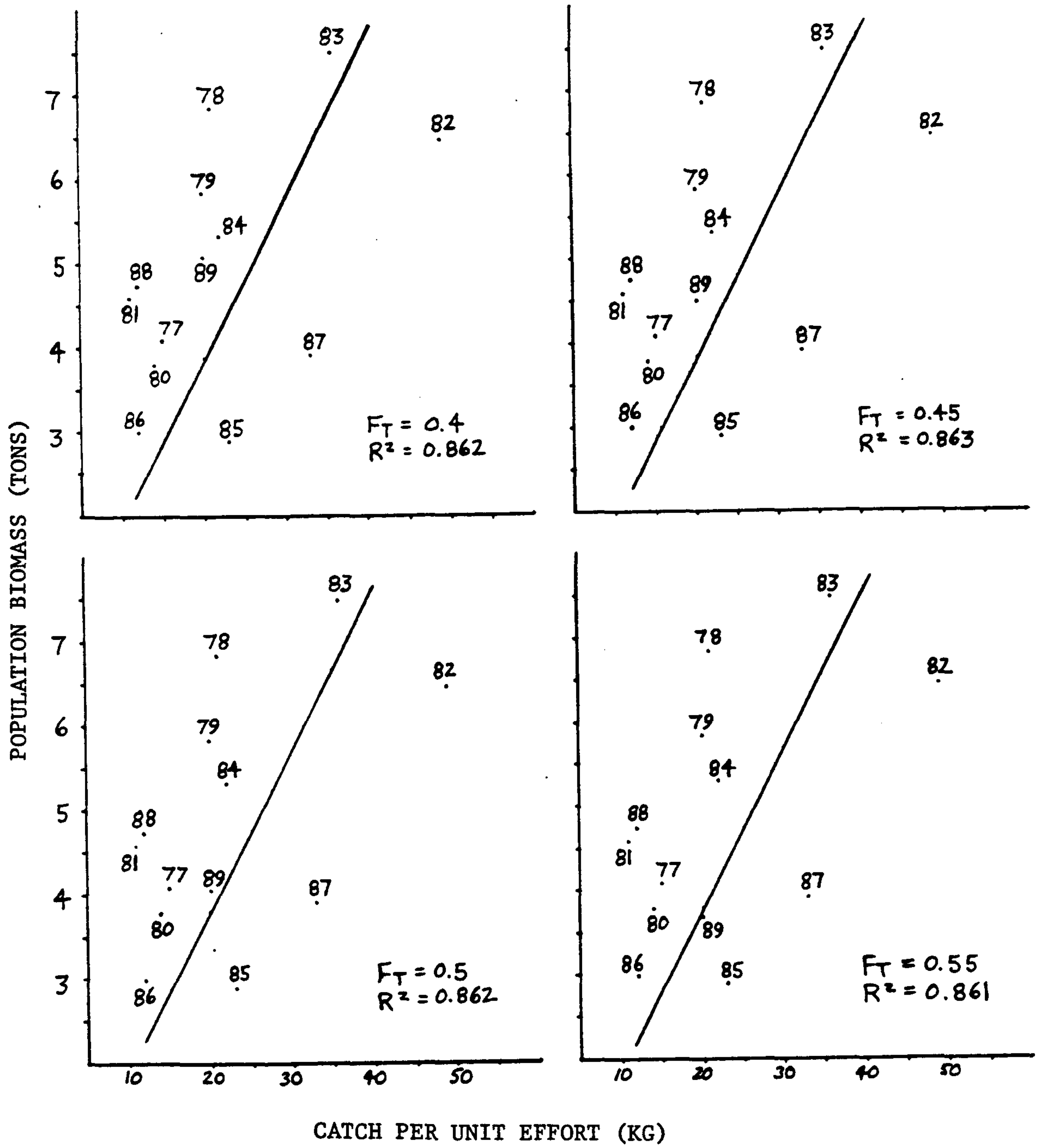

Fig. 12. Regressions of estimated average population biomass of age 12 fish on inshore catch rate using a zero intercept model.

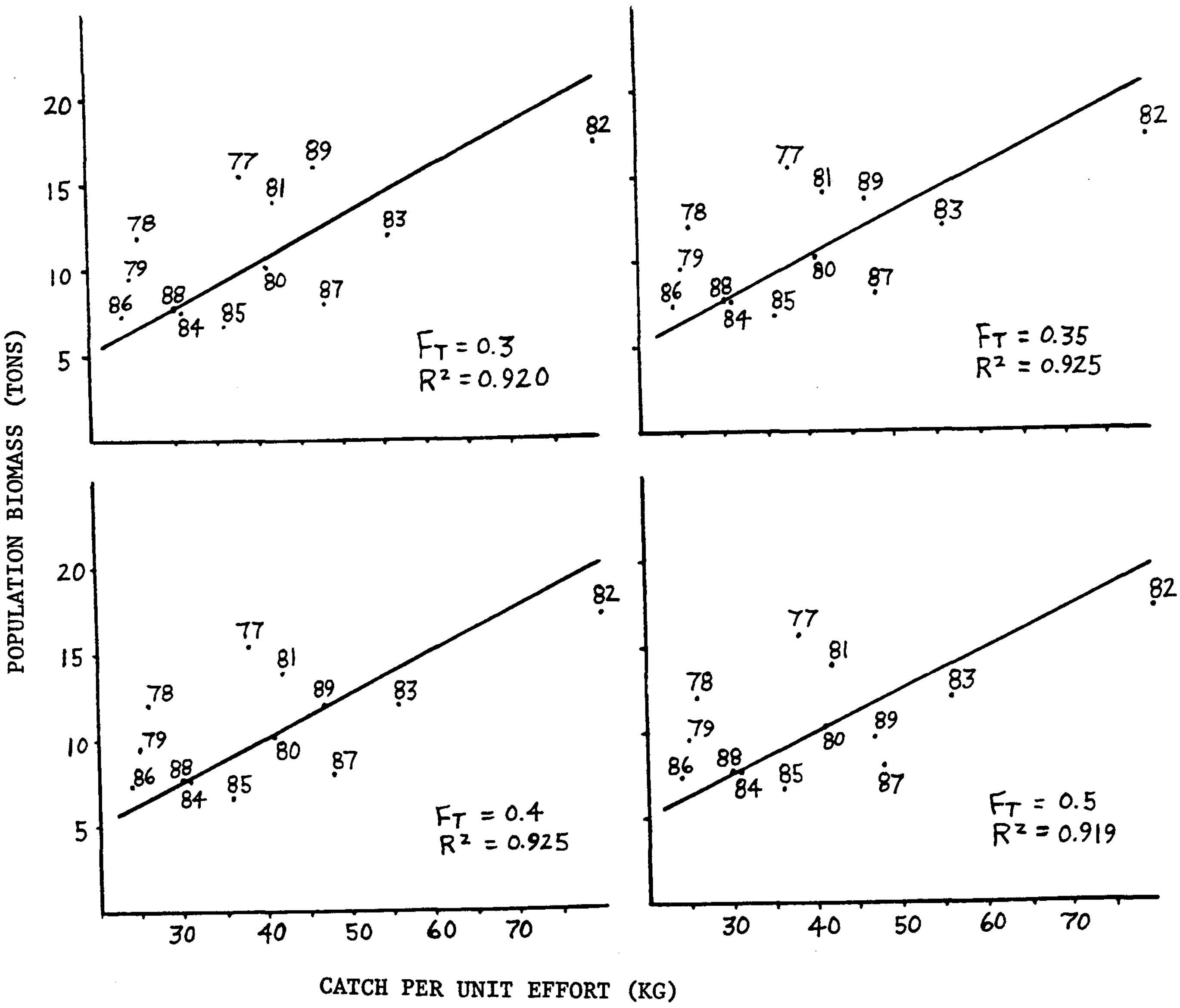

Fig. 13. Regressions of estimated average population biomass of age 11 fish on inshore catch rate using a zero intercept model.

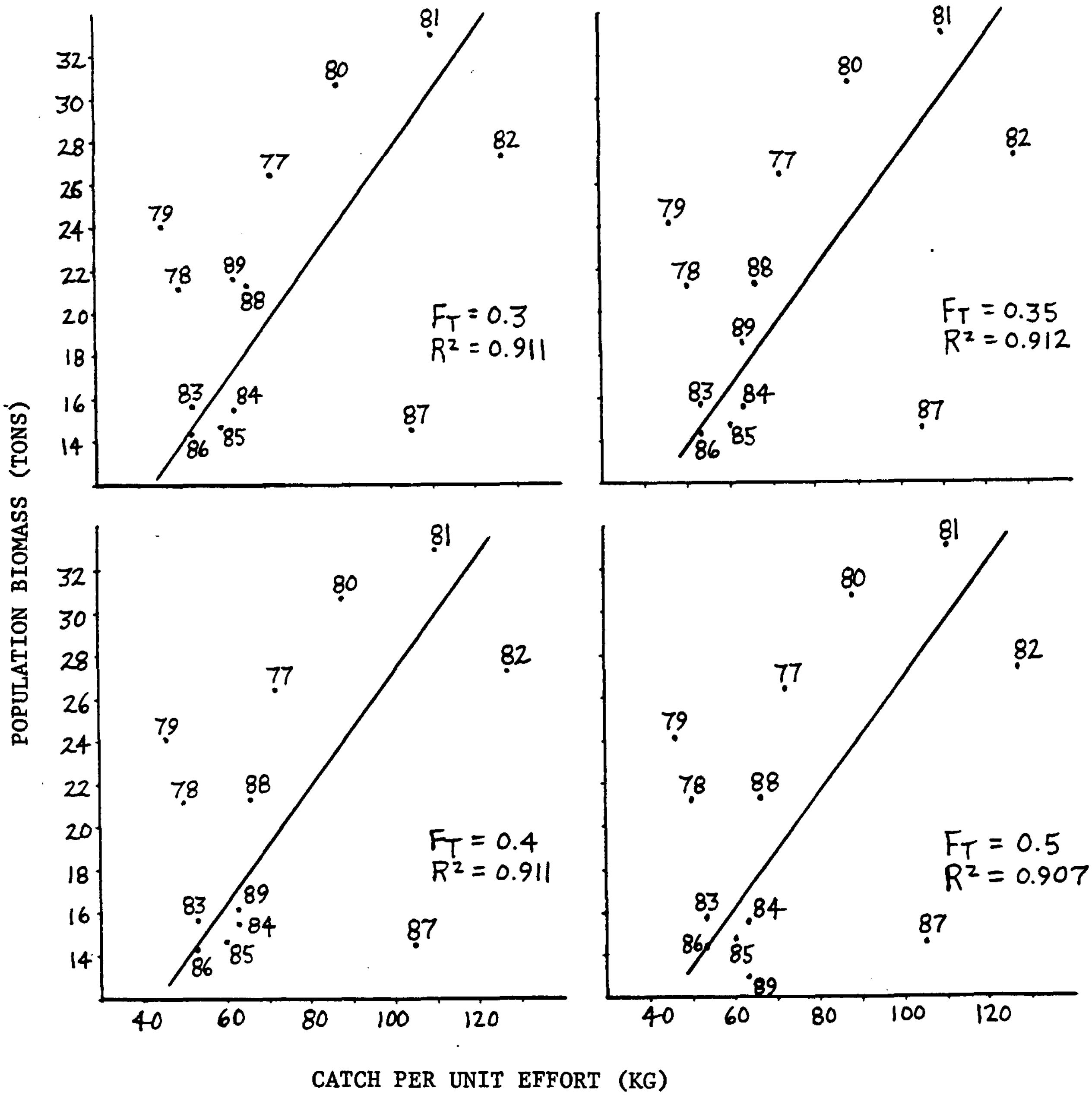

Fig. 14. Regressions of estimated average population biomass of age 10 fish on inshore catch rate using a zero intercept model.