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ANNUAL ASSESSMENT OF HERRING IN NAFO DIVISION 4T

by

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ABSTRACT

Reported landings of herring in NAFO Division 4T in 1984 (25489 t) were similar to the 1983 level. Gillnet catch rates in both spring and fall fisheries were also similar to 1983 rates. Annual gillnet effort was estimated from these rates, and Sequential Population Analyses were fine tuned by comparing the age-specific catch rates (ages 4, 5 and 6) with population estimates at age. Partial recruitment parameters were estimated from new gillnet selectivity information. For spring spawners, the fully recruited F was estimated to be 0.2; whereas the fall spawner value was estimated to be 0.5 in 1984. The 1980 year-classes of spring and fall spawners were strong (estimated at 118 million at age 2 in 1982 for spring and at 214 million at age 2 in 1982 for fall). The $F_{0.1}$ catch of spring spawners in 1986 is predicted to be 9,100 tonnes, and the $F_{0.1}$ catch of fall spawners in 1986 is predicted to be 10,800 tonnes.

RÉSUMÉ

Les débarquements de hareng rapportés dans la Division 4T de l'OPANO en 1984 (25489 t) étaient semblables à ceux de 1983. Les taux de capture des filets maillants au printemps et à l'automne étaient semblables aux niveaux de 1983. Ces taux ont été utilisés pour estimer l'effort annuel des filets, et les analyses séquentielles de populations ont été ajustées en comparant les taux de captures à l'âge (âges 4, 5 et 6) et les estimations de population à l'âge. Les valeurs du recruitement partiel ont été estimées à partir de nouvelles informations sur la sélectivité des filets. Pour les reproducteurs de printemps pleinement recrutés, on a estimé que F = 0,2; tandis que la valeur pour les reproducteurs d'automne a été évaluée à F = 0,5 en 1984. Les classes d'année de 1980 des reproducteurs de printemps et d'automne étaient fortes (évaluée à 118 millions à l'âge 2 en 1982 pour le printemps et à 214 millions à l'âge 2 en 1982 pour l'automne). Les captures de reproducteurs de printemps en 1986 à $F_{0,1}$ seront de 9,100 tonnes et les captures de reproducteurs d'automne à $F_{0,1}$ seront de 10,800 tonnes.

1. Introduction

Prior to 1965, the southern Gulf of St. Lawrence (NAFO Division 4T, Figure 1) herring stock complex was exploited primarily by gillnets. Traps were used on the Magdalen Islands. Most fishing was conducted on spawning grounds in May, August, and September. Total annual landings averaged 32,925 tonnes between 1949 and 1964, varying from 18,819 to 42,940 tonnes. Subsequently, a purse seine fishery developed, which concentrated on feeding, migrating, and overwintering herring schools. By 1968, landings occurred in every month of the year. The winter fishery was concentrated along the shore of southwestern Newfoundland (NAFO Subdivision 3Pn) where landings reached a maximum in excess of 95,000 tonnes in 1969, only to decline and disappear by 1973. 4T landings attained a maximum in excess of 175,000 tonnes in 1970 (Table 1), but declined rapidly as a result of reduced abundance of herring.

A total allowable catch (TAC) of 55,000 tonnes was first set in 1975. It was reduced to 16,000 tonnes in 1981 and has not exceeded 20,000 t since then. Nominal catches were considerably greater than these recent regulations (Table 1). However, catch statistics are unreliable as an indicator of total removals. Most catches of herring for bait are not reported; unsaleable fish are often discarded; and underreporting is known to occur.

Tagging studies have shown that some portion of the 4T herring populations overwinters in the Sydney Bight (NAFO Subdivision 4Vn), where a winter purse seine fishery occurs. It is not possible to estimate accurately the quantity of 4T herring caught in that fishery.

1984 landings in the southern Gulf were comparable in quantity to those of 1983 (Table 1). Spring gillnet landings declined due to a regulatory closure, but fall landings reached a recent record high level (Table 2).

2. Input data

a) Commercial fishery data

Samples from commercial landings were used to determine the catch at age of each of the two major spawning groups, and for calculation of their average weights at age. As gillnetters generally fish spawning concentrations, landings in the spring gillnet fishery (prior to July 1) are usually of spring spawners while fall gillnetters usually capture fall spawners. Most fish caught in gillnets are in spawning or pre-spawning condition (gonad stages 5 and 6). The fall purse seine fishery captures a mixture of spring and fall spawners, which are identified by their maturity stages. Total annual catches from each spawning group by each of the major gears are presented in Table 3.

The average landed weight per trip by gillnetters was obtained from purchase slips (Table 4). These values were divided by estimates of the average numbers of nets per trip (based upon questionnaires) to update an index of catch per net day. Separate indices were calculated for spring and fall gillnet fisheries, and 1984 values were similar to those for 1983 (Table 5).

An estimate of purse seine catch per set was derived from logbooks. In 1984, seine catch rates (42.4 tonnes per set) reached their highest value since 1978 (Table 6).

b) Research Survey Data

i) Herring spawning bed survey: Between May 1 and June 1, 1984, the historical spring herring spawning area in Miramichi Bay was surveyed by SCUBA divers. Four spawning beds were located.

The sizes of the spawning beds ranged from 445,000 to 1,100,000 m^2. Mean number of eggs/m^2 ranged from 34.3×10^3 to 166.9×10^3. This shows an increase in egg abundance compared to the 1983 survey.

The herring spawning biomass was estimated at 2,236.5 tonnes (S. Messieh, pers. comm.). Taking into account the reported spring catch in that area, the local exploitation rate may be estimated at 59.3%. This rate is much lower than that of 1983, reported as 83.7 - 96.9 (Messieh, MS1985).

ii) Gillnet selectivity: Experimental fishing with four different mesh sizes of gillnets was conducted (Ahrens and Chouinard, unpublished). Log-linear regressions were fitted to the ratios of catches between net pairs and herring length (Figure 2). These regressions were transformed into selectivity curves corresponding to a slightly skewed normal distribution, according to a method described by Regier and Robson (1966). Data from all two-net comparisons were used to derive an average relationship between mesh size and modal selection length (Figure 3). Mean selection curves for the four experimental nets are shown in Figure 4. These results were subsequently used in partial recruitment calculations (see below).

3. Estimation of Parameters

a) Partial recruitment: For spring and fall spawners separately, the combined selectivity ogive for the gillnet fishery was calculated by weighting the gillnet selection curves by their frequency of use in the fishery (known from interviews). Selectivity at age was calculated by multiplying the vector of selectivity at length by the age-length key. Partial recruitment to the gillnet fishery was then estimated as the product of selectivity at age and maturity at age, since it is assumed that immature fish are unavailable to gillnet fisheries concentrated on spawning runs. The resulting partial recruitment vector was standardized to 1.0 at its highest value. Partial recruitment to the seine fishery was assumed to be 1.0 for ages 3 and older. An overall partial recruitment vector was calculated by weighting the partial recruitment of seines and gillnets by their relative contribution to the total landings in 1984. The results were as follows:

AGE	3	4	5	6	7	8	9+
Spring PR	.47	1.0	1.0	0.5	0.34	0.2	0.15
Fall PR	.03	0.5	1.0	0.85	0.63	0.53	0.5

The differences between the spring and fall values reflect the larger mesh sizes used in the fall gillnet fishery and the later age at maturity of fall spawners.

b) Weights at age: From 1971 to 1973, weights at age for this stock were determined from samples from the winter purse seine fishery in Subdivision 3Pn. When this fishery ceased, weights were taken from the spring fishery along the Edge of the Laurentian Channel (1974 to 1980) (Winters, pers. comm.). Closure of the Edge fishery resulted in the use of spring gillnet samples for 1981 and 1982 (Cleary, pers. comm.). For the last two years, weights have been estimated from a weighted average of fish weights observed in all 4T herring fisheries. These changes in methodology, combined with overestimates of weights of fish older than age 11, resulted in a weight-at-age matrix in last year's assessment which did not match reported nominal catches when multiplied by the catch-at-age matrix. This situation was corrected this year by using observed average weights for ages 2 to 11+ for each year in the period 1971 to 1976, and an average of 1981 to 1984 weights for the period 1977 to 1984. (Table 7 and 8).

c) Catch Matrices: Catch at age for 1971 to 1982 was taken from Ahrens and Nielsen (MS1984). The catch at age of spring spawners was once again dominated by very few year-classes (Table 9). The 1979 year-class was still strong in 1984, but four year olds were also abundant. The catch at age of fall spawners still included large numbers from the 1978 and 1979 year-classes (Table 10).

Separate catches at age for the major gears are shown in Tables 11 to 14.

Recent assessments of 4T herring stocks have used a catch matrix "extended" to age 20 (Cleary, MS1983; Ahrens and Nielsen, MS1984). Although ages are only determined reliably up to age 11, catches at age of older fish were estimated by assuming that catches of successive cohorts would retain the same relative values as they had between ages 10 and 11 as they progressed from age 10 to age 20 (diagonally down the catch matrix). This procedure may introduce invalid assumptions about age-specific survival and fishing mortality for older age classes. Therefore, the present assessment was conducted using the catch matrix for ages 2-10 only for sequential population analysis. The vector of catches at ages 11+ was added to the matrix for calculation of population biomass and for catch projections.

A simulation of the impact upon the accuracy of projected catches of a constant unreported catch was conducted. A constant additional catch of 4,000 t per year was prorated over each year of the spring catch matrix for the period 1971 to 1984. With all other input parameters equal, sequential population analyses and projections were compared with the results using nominal catches only. Projected catches at $F_{0.1}$ were 4,000 t per year higher using the augmented catch matrix. It was therefore concluded that a constant unreported catch would not substantially affect the accuracy of the assessment.

d) Fishing mortality at ages 10 and 11+: Fishing mortality rates at older ages were chosen to provide an approximate balance between population abundance and catch at age n in year m and population abundance at age n + 1 in year m + 1.

e) Fishing mortality for the last year: The annual gillnet catch of spring and fall spawners separately was divided by the appropriate gillnet catch rate to estimate annual gillnet effort (Table 15). Fully recruited F was chosen on the basis of regressions between gillnet catch numbers at age per unit effort and estimated population at age. The best relationships were chosen on the basis of the proximity of the 1983 and 1984 values to the regression line, maximization of the correlation coefficient, and minimization of the intercept. This procedure was carried out for ages 4, 5, and 6 with data covering the period 1974 to 1984. (Tables 16 and 17; Figures 5 to 10). For purposes of comparison and validation, the same regressions were run at the chosen F using the output of a sequential population analysis based upon the extended (to age 20) catch matrix. Differences between the two approaches were very small (Table 18).

4. Assessment Results

a) Spring Spawners: The fully recruited F in 1984 was estimated to be 0.2. The 1979 year-class predominated for the third consecutive year and its abundance at age 2 in 1981 was estimated at 232 million fish. The 1980 year-class is also quite strong (about 118 million fish at age 2 in 1982). The following estimates of 3+ population biomass were obtained from Sequential Population Analysis ('000 t):

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
162	129	97	86	80	60	84	62	39	31

1981	1982	1983	1984
22	46	54	50

The plot of the regression between these values and total spring gillnet catch rates is shown in Figure 11. SPA output is in Tables 19 to 21.

b) Fall Spawners: The fully recruited F in 1984 was estimated to be 0.5. The 1980 year-class predominated in the 1984 fishery and its abundance at age 2 in 1982 was estimated at 214 million fish. This is stronger than the 1979 year-class (144 million) but not as strong as the 1977 (244 million). The following estimates of 4+ population biomass were obtained from Sequential Population Analysis ('000 t):

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
375	179	110	116	89	66	66	63	54	32

1981	1982	1983	1984
48	57	59	73

The plot of the regression between these values and total fall gillnet catch rates is shown in Figure 12. SPA output is in Tables 22 to 24.

5. Prognoses

For catch projections recruitment at age 2 in 1984 and subsequent years was set at the geometric mean level for the period 1973 to 1982. Partial recruitment in the period 1985 to 1987 was assumed to be as observed in 1984. The results were as follows:

	TAC	$F_{0.1}$ = 0.3	
Spring Spawners	1985	1986	1987
Catch ('000 t)	7.5	9.1	9.4
3+ biomass ('000 t)	54	56	58
Fully recruited F	0.26	0.30	0.30

Detailed spring spawner projections are in Table 25.

Fall Spawners			
Catch ('000 t)	18.5	10.8	11.2
4+ biomass ('000 t)	68	62	63
Fully recruited F	0.48	0.30	0.30

Detailed fall spawner projections are in Table 26.

These projected catches rely heavily upon a few recently recruited year-classes. Population biomass levels remain very low compared with those 15 years ago and are not expected to increase substantially under the present management regime, particularly in the case of fall spawners where exploitation rates remain well above $F_{0.1}$.

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Table 1: Herring landings in NAFO division 4T, 1967 to 1984

Year	January	Feb.	March	April	May	June	July	August	Sept.	October	Nov.	Dec.	Total
1967	1742	-	-	409	25220	8764	5679	10718	4620	1358	3095	1131	62736
1968	546	442	806	6455	24239	2566	15847	19768	22350	5284	13057	770	112130
1969	-	-	73	9329	17701	6568	35476	46987	22448	4169	11543	121	154415
1970	-	55	-	21211	15782	2545	51002	36860	24959	18506	3831	746	175497
1971	-	-	42	10644	11895	4809	41521	23067	36282	5163	1053	370	134846
1972	-	-	-	400	6102	2583	11034	9092	14453	7777	2108	41	53590
1973	-	-	-	1876	12801	4221	2135	7737	9436	2079	69	3	40357
1974	-	-	-	1302	14474	1190	2958	3143	7282	3081	1714	9	35153
1975	-	-	-	4028	20229	1428	289	2398	4646	8986	2256	305	44565
1976	-	-	-	8461	14406	961	193	1082	1807	5244	6973	326	39453
1977	-	-	-	7625	8338	8850	244	2125	1148	7166	8726	602	44824
1978	240	-	-	2046	13363	883	526	2487	10095	13672	6981	2848	53141
1979	-	-	-	14072	6158	1113	680	1766	6381	5071	9904	2598	47743
1980	80	-	15	10458	9220	1032	910	2224	1952	9011	5001	540	40443
1981	-	-	13	1736	4566	729	1588	5119	3986	2171	1246	-	21154
1982	-	-	-	199	5667	876	442	5592	8047	3122	36	-	23981
1983	-	-	-	263	7282	1000	851	10291	2735	2160	1291	-	25873
1984*	-	-	-	86	4177	1020	653	5489	9685	4065	314	-	25489

*preliminary

Table 2: Catches (t) of herring by gear and by season in NAFO Division 4T, 1971-1984

	GILLNETS (and other inshore)		SEINES (and other offshore)		
YEAR	SPRING	FALL	SPRING	FALL	TOTAL
1971	14074	10327	13316	97129	134846
1972	8137	9585	948	34910	53580
1973	11713	7920	7185	13539	40357
1974	8285	4199	8681	13988	35153
1975	7119	4741	18566	14139	44565
1976	6611	3419	17217	12206	39483
1977	4926	3285	19887	16726	44824
1978	8484	4853	8048	31756	53141
1979	7444	5780	13899	20620	47743
1980	6443	6784	13330	13886	40443
1981	6545	10926	20	4552	22043
1982	6742	14130	0	3109	23981
1983	8545	13858	0	3470	25873
1984*	5283	17267	0	3050	25600

* preliminary

Table 3: Catches (t) of herring by gear and by spawning group in NAFO Division 4T, 1974 to 1984

	GILLNETS		SEINES		
YEAR	SPRING	FALL	SPRING	FALL	TOTAL*
1974	8646	5012	5708	14014	33380
1975	7355	3130	17421	17018	44924
1976	7314	3026	16109	15845	42294
1977	6060	2897	17663	18206	44826
1978	9789	4895	15058	24362	54104
1979	8062	4510	9663	24797	47032
1980	8266	3911	10146	15714	38037
1981	5356	10727	2451	1793	20327
1982	6743	13148	328	3066	23285
1983	8226	13934	1611	1909	25680
1984**	4885	17684	1773	1206	25548

* Values in this table are based on the cross products of the catch matrices and the weight matrices. Consequently, totals may vary slightly from reported landed weights in Table 2.

** preliminary

Table 4: Catch (t) per successful trip for gillnet herring fisheries in NAFO Division 4T, 1973-1984.

YEAR	SPRING FISHERY (Jan - June)	FALL FISHERY (July - Dec.)
1973	2.09	2.66
1974	1.23	2.99
1975	1.29	3.63
1976	1.34	3.13
1977	1.89	3.56
1978	2.22	3.21
1979	1.49	1.78
1980	1.09	1.45
1981	0.92	2.15
1982	1.73	2.33
1983	1.79	3.45
1984	1.65	3.42

Table 5: Catch (t) per net per trip for gillnet herring fisheries in NAFO Division 4T, 1973 - 1984.

YEAR	SPRING FISHERY (Jan - June)	FALL FISHERY (July - Dec)
1973	.079	.375
1974	.050	.393
1975	.044	.504
1976	.045	.352
1977	.066	.383
1978	.072	.282
1979	.040	.156
1980	.034	.132
1981	.027	.196
1982	.052	.212
1983	.054	.314
1984	.050	.311

Table 6: Catch (t) per set in the fall purse seine herring fishery in NAFO Division 4T, 1969 - 1984

YEAR	FALL FISHERY
1969	110.2
1970	90.9
1971	56.7
1972	45.1
1973	41.5
1974	37.9
1975	34.5
1976	40.6
1977	44.4
1978	44.3
1979	24.5
1980	18.7
1981	26.6
1982	N/A
1983	35.5
1984	42.4

Table 7:

4T Herring Spring Spawners :Wts-at-age (kg)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	0.075	0.075	0.087	0.095	0.090	0.104	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
3 :	0.103	0.140	0.141	0.160	0.154	0.177	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172
4 :	0.185	0.207	0.184	0.202	0.185	0.210	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213
5 :	0.221	0.233	0.219	0.238	0.229	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247	0.247
6 :	0.243	0.274	0.267	0.275	0.266	0.275	0.287	0.287	0.287	0.287	0.287	0.287	0.287	0.287
7 :	0.268	0.311	0.282	0.291	0.298	0.271	0.291	0.291	0.291	0.291	0.291	0.291	0.291	0.291
8 :	0.292	0.318	0.310	0.319	0.304	0.304	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310
9 :	0.290	0.339	0.327	0.320	0.316	0.310	0.348	0.348	0.348	0.348	0.348	0.348	0.348	0.348
10 :	0.301	0.323	0.332	0.328	0.329	0.333	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
11+:	0.319	0.344	0.374	0.348	0.357	0.353	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359

Table 8:

4T Herring Fall Spawners :Wts-at-age (kg)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	0.040	0.040	0.040	0.047	0.040	0.035	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119
3 :	0.093	0.053	0.100	0.126	0.115	0.111	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177
4 :	0.142	0.168	0.170	0.190	0.169	0.184	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
5 :	0.189	0.194	0.206	0.235	0.215	0.217	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283
6 :	0.129	0.238	0.242	0.255	0.248	0.253	0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313
7 :	0.234	0.253	0.269	0.283	0.272	0.276	0.338	0.338	0.338	0.338	0.338	0.338	0.338	0.338
8 :	0.248	0.262	0.292	0.314	0.288	0.283	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359
9 :	0.264	0.277	0.295	0.327	0.314	0.300	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
10 :	0.272	0.287	0.313	0.331	0.325	0.323	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364
11+:	0.297	0.312	0.342	0.354	0.362	0.349	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395

Table 9:

4T Herring Spring Spawners :Catch-at-age (1000's)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	3200.	100.	1600.	4600.	1600.	17300.	3300.	14300.	21700.	20300.	5700.	1000.	429.	204.
3 :	65700.	2100.	1700.	8700.	26800.	9100.	60300.	14700.	13300.	39800.	16400.	29600.	10851.	3912.
4 :	6800.	27500.	2500.	3300.	19200.	29300.	7400.	67700.	5700.	5300.	7600.	5500.	30938.	11388.
5 :	13600.	5800.	31700.	1700.	3200.	7200.	10800.	4800.	32900.	2900.	1200.	1300.	3901.	12265.
6 :	9300.	5000.	6100.	21900.	16800.	2400.	3600.	7100.	2100.	14700.	800.	300.	1095.	1200.
7 :	8800.	3300.	3900.	3800.	20100.	500.	600.	1300.	3000.	3100.	4100.	200.	70.	185.
8 :	14300.	3900.	6000.	4100.	2500.	9400.	500.	1200.	700.	1900.	700.	300.	51.	59.
9 :	15000.	4500.	2300.	6000.	3300.	1100.	6600.	200.	200.	700.	700.	100.	17.	63.
10 :	5000.	4900.	2300.	900.	5300.	1600.	500.	3700.	700.	300.	100.	1.	1.	117.
11+:	67507.	4006.	4905.	2305.	6203.	21402.	13501.	2102.	3402.	2702.	1104.	96.	10.	75.
2+ :	209207.	61106.	63005.	57305.	105003.	99302.	107101.	117102.	83702.	91702.	38404.	38397.	47363.	29468.

Table 10:

4T Herring Fall Spawners :Catch-at-age (1000's)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	4900.	5700.	1700.	4700.	100.	100.	200.	1500.	2900.	1300.	100.	200.	34.	9.
3 :	33100.	5200.	3300.	5000.	2200.	300.	3000.	19200.	6200.	30600.	9300.	9400.	4831.	1407.
4 :	92800.	15600.	4500.	16200.	4100.	1900.	7900.	27600.	34600.	9400.	30600.	19700.	23688.	27957.
5 :	35300.	51100.	7900.	5700.	25500.	5400.	3600.	14300.	27400.	22000.	5500.	23800.	10871.	18223.
6 :	59800.	20800.	19800.	3800.	7000.	31200.	3600.	4000.	11000.	7900.	2400.	5100.	13530.	12253.
7 :	87600.	28500.	9000.	9700.	3300.	4500.	22400.	3500.	2300.	3900.	900.	2100.	2389.	6257.
8 :	114300.	26200.	11800.	2500.	5000.	2000.	2200.	14100.	3100.	600.	900.	900.	1850.	1375.
9 :	57800.	23400.	7400.	5200.	2200.	3800.	1400.	1600.	5200.	800.	200.	600.	617.	364.
10 :	30900.	11500.	9500.	3900.	3700.	800.	2800.	900.	700.	300.	100.	36.	114.	102.
11+:	221407.	73506.	14905.	17704.	21403.	17802.	16601.	16300.	10300.	2800.	803.	164.	307.	106.
2+ :	737907.	261506.	89805.	74404.	74503.	67802.	63701.	103000.	103700.	79600.	50803.	62000.	58231.	68053.

Table 11:

GILLNET CATCH OF SPRING SPAWNERS

	74	75	76	77	78	79	80	81	82	83	84
2	118	7	0	102	42	52	498	41	60	0	13
3	5373	13150	2411	16498	7111	7289	20455	11996	28737	5107	2104
4	2160	3280	18619	3900	30093	2905	3284	6929	5331	28897	7803
5	1303	1217	2379	4361	1526	19865	1294	1169	1312	3609	10114
6	15351	1585	552	638	2094	529	8771	723	287	1009	858
7	2844	5899	100	50	347	1335	199	2943	156	36	118
8	2486	1702	3038	70	288	105	989	73	293	1	48
9	2770	1439	432	1281	106	60	96	262	145	1	52
10	370	2334	301	1	1498	344	129	35	91	1	117
11+	513	1468	2984	1768	1282	1590	1965	929	96	1	28

Table 12:

GILLNET CATCH OF FALL SPAWNERS

	74	75	76	77	78	79	80	81	82	83	84
2	0	0	0	0	6	0	23	0	0	0	0
3	137	0	40	144	387	122	6679	6307	3145	784	1188
4	4659	1397	285	2221	4832	7424	3032	26569	16555	21425	26804
5	1931	7117	1500	402	3418	3633	3708	5097	20671	10357	16722
6	563	1070	6020	299	653	1790	855	2275	4713	12415	11406
7	2053	647	479	3799	676	382	770	897	1998	2200	5736
8	197	537	251	157	3788	460	170	764	852	1764	1291
9	2265	351	432	96	91	660	193	96	436	583	328
10	799	275	52	553	196	10	128	49	116	80	102
11+	5266	1569	2209	1373	1965	1348	571	797	54	257	102

Table 13:

SEINE CATCH OF SPRING SPAWNERS

	74	75	76	77	78	79	80	81	82	83	84
2	4482	1593	17300	3198	14258	21648	19802	5659	940	429	191
3	3327	13650	6689	43802	7589	6011	19345	4404	863	5744	1808
4	1140	15920	10681	3500	37607	2795	2016	671	169	2041	3585
5	397	1983	4821	6439	3274	13036	1606	32	0	292	2151
6	6549	15216	1848	2962	5006	1571	5929	77	13	86	342
7	956	14201	400	550	953	1665	2901	1158	44	34	67
8	1614	798	6362	430	912	595	911	627	7	50	11
9	3230	1861	668	5319	94	140	604	438	0	16	11
10	530	2966	1299	499	2202	356	171	65	0	0	0
11+	1792	4735	18418	11733	820	1812	737	175	0	9	47

Table 14:

SEINE CATCH OF FALL SPAWNERS

	74	75	76	77	78	79	80	81	82	83	84
2	4700	100	100	200	1494	2900	1277	100	200	34	9
3	4863	2200	260	2856	18813	6078	23921	2993	6255	4047	219
4	11541	2703	1615	5679	22768	27176	6368	4031	3145	2263	1153
5	3769	18383	3900	3198	10882	23767	18292	403	3129	514	1501
6	3237	5931	25180	3301	3347	9210	7045	125	387	1115	847
7	7647	2653	4021	18601	2824	1918	3130	3	102	189	521
8	2303	4463	1750	2044	10312	2640	430	137	48	86	8
9	2935	1849	3368	1304	1509	4540	607	104	164	34	36
10	3101	3425	748	2247	705	690	172	51	0	34	0
11+	12438	19834	15593	15228	14335	8953	2229	6	110	50	4

Table 15: Annual gillnet effort indices. The values are comparable within, but not between, columns.

Year	Spring Fishery	Fall Fishery
1974	172.9	12.75
1975	167.2	6.21
1976	162.5	8.60
1977	91.8	7.56
1978	136.0	17.36
1979	201.6	28.91
1980	243.1	29.63
1981	198.4	54.73
1982	129.7	62.02
1983	152.3	44.38
1984	97.7	56.86

Table 16: Spring spawner fine tuning. A terminal F = 0.2 was chosen. See text for details.

AGE 4

Trial F	Coefficient of determination	1984 Residual	Intercept
.10	.85	-52305	10391
.15	.94	-23471	8325
.175	.95	-13874	7637
.20	.95	- 9078	7294
.225	.94	- 3456	6891
.25	.93	- 460	6676
.30	.91	5271	6264
.40	.86	12406	5751

AGE 5

Trial F	Coefficient of determination	1984 Residual	Intercept
.10	.86	-29099	6049
.15	.91	- 9655	7442
.175	.91	- 3184	7906
.20	.90	46	8137
.225	.87	3835	8409
.25	.86	5852	8554
.30	.80	9713	8830
.40	.70	14514	9173

AGE 6

Trial F	Coefficient of determination	1984 Residual	Intercept
.10	.96	-11963	5867
.15	.96	- 5188	3777
.175	.96	- 2930	3081
.20	.96	- 1801	2733
.225	.95	- 477	2323
.25	.95	229	2106
.30	.95	1580	1688
.40	.94	3269	1165

Table 17: Fall spawner fine tuning. A terminal F = 0.5 was chosen. See text for details.

AGE 4

Trial F	Coefficient of determination	1984 Residual	Intercept
.10	.52	289120	-66079
.30	.64	52740	2543
.50	.51	5525	16221
.525	.49	1523	17377
.55	.48	- 901	18078
.575	.46	- 4226	19038
.60	.45	- 6258	19625

AGE 5

Trial F	Coefficient of determination	1984 Residual	Intercept
.10	.18		68118
.30	.77	14238	29236
.50	.91	- 4623	21493
.525	.92	- 6209	20838
.55	.92	- 7167	20442
.575	.93	- 8479	19900
.60	.93	- 9278	19569

AGE 6

Trial F	Coefficient of determination	1984 Residual	Intercept
.10	.33		29444
.30	.89	20309	12790
.50	.98	3861	9470
.525	.98	2744	9189
.55	.98	1635	9018
.575	.98	486	8786
.60	.98	215	8643

Table 18: Coefficients of determination based upon SPA output using "short" (ages 2 to 10) and "long" (ages 2 to 20) catch matrices at the chosen terminal F values. See text for details.

SPRING SPAWNERS (F = 0.2)

AGE	SHORT CATCH MATRIX	LONG CATCH MATRIX
4	.95	.95
5	.90	.91
6	.96	.95

FALL SPAWNERS (F = 0.5)

AGE	SHORT CATCH MATRIX	LONG CATCH MATRIX
4	.51	.51
5	.91	.91
6	.98	.98

Table 19:

4T Herring Spring Spawners :Population (1000's)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	70040.	30306.	78967.	146389.	54739.	346413.	50658.	50879.	102607.	92004.	232278.	118757.	59142.	140784.
3 :	369778.	54456.	24722.	63208.	115700.	43372.	268007.	38498.	28817.	64491.	57073.	185027.	96327.	48034.
4 :	47715.	243614.	42689.	18707.	43913.	70636.	27325.	165210.	18359.	11717.	17488.	32006.	124834.	69085.
5 :	62743.	32940.	174668.	32695.	12346.	18793.	31626.	15726.	74704.	9917.	4859.	7525.	21253.	74405.
6 :	86516.	39140.	21749.	114476.	25234.	7233.	8941.	16213.	8569.	31762.	5517.	2900.	4991.	13890.
7 :	37655.	62450.	27540.	12330.	74019.	5792.	3770.	4099.	6929.	5128.	12878.	3796.	2104.	3101.
8 :	36194.	22919.	48152.	19034.	6685.	42551.	4291.	2546.	2190.	2991.	1447.	6866.	2927.	1659.
9 :	51184.	16836.	15254.	34017.	11897.	3235.	26386.	3063.	1014.	1165.	765.	560.	5351.	2351.
10 :	17340.	28443.	9742.	10417.	22450.	6777.	1662.	15673.	2327.	650.	332.	23.	368.	4366.
11+:	123677.	31652.	29756.	26680.	26275.	37912.	26698.	8904.	14410.	7514.	3670.	2170.	2212.	2799.
2+ :	902844.	562756.	473238.	477953.	393259.	582715.	449365.	320812.	259926.	227341.	336307.	359629.	319510.	360474.

Table 20:

4T Herring Spring Spawners :Fishing Mortality

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	0.051	0.003	0.022	0.035	0.032	0.056	0.074	0.368	0.264	0.277	0.027	0.009	0.008	0.001
3 :	0.217	0.043	0.078	0.164	0.293	0.262	0.284	0.541	0.700	1.105	0.378	0.194	0.132	0.094
4 :	0.171	0.133	0.066	0.216	0.649	0.604	0.352	0.594	0.416	0.680	0.643	0.209	0.317	0.200
5 :	0.272	0.215	0.223	0.059	0.335	0.543	0.468	0.407	0.655	0.387	0.316	0.211	0.225	0.200
6 :	0.126	0.152	0.368	0.236	1.272	0.452	0.580	0.650	0.313	0.703	0.174	0.121	0.276	0.100
7 :	0.296	0.060	0.169	0.412	0.354	0.099	0.192	0.427	0.640	1.066	0.429	0.059	0.037	0.068
8 :	0.565	0.207	0.148	0.270	0.526	0.278	0.137	0.721	0.431	1.164	0.749	0.049	0.019	0.040
9 :	0.388	0.347	0.181	0.216	0.363	0.466	0.321	0.074	0.244	1.054	3.321	0.219	0.003	0.030
10 :	0.380	0.210	0.300	0.100	0.300	0.300	0.400	0.300	0.400	0.700	0.400	0.050	0.003	0.030
11+:	0.900	0.150	0.200	0.100	0.300	0.950	0.800	0.300	0.300	0.500	0.400	0.050	0.005	0.030

Table 21:

4T Herring Spring Spawners :Population Biomass (tonnes)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	5253.	2273.	6870.	13907.	4927.	36027.	6738.	6767.	13647.	12237.	30893.	15795.	7866.	18724.
3 :	38087.	7624.	3486.	10113.	17818.	7677.	46097.	6622.	4957.	11093.	9817.	31825.	16568.	8262.
4 :	8827.	50428.	7855.	3779.	8124.	14834.	5820.	35190.	3910.	2496.	3725.	6817.	26590.	14715.
5 :	13866.	7675.	38252.	7781.	2827.	4642.	7812.	3884.	18452.	2450.	1200.	1859.	5250.	18378.
6 :	21023.	10724.	5807.	31481.	6712.	1989.	2566.	4653.	2459.	9116.	1583.	832.	1432.	3986.
7 :	10092.	19422.	7766.	3588.	22058.	1570.	1097.	1193.	2016.	1492.	3748.	1105.	612.	903.
8 :	10569.	7288.	14927.	6072.	2032.	12936.	1330.	789.	679.	927.	448.	2129.	908.	514.
9 :	14843.	5707.	4988.	10885.	3759.	1003.	9182.	1066.	353.	406.	266.	195.	1862.	818.
10 :	5219.	9187.	3234.	3417.	7386.	2257.	539.	5078.	754.	211.	108.	7.	119.	1414.
11+:	39453.	10888.	11129.	9285.	9380.	13383.	9585.	3197.	5173.	2698.	1318.	779.	794.	1005.
2+ :	167233.	131217.	104315.	100308.	85023.	96316.	90765.	68438.	52400.	43123.	53105.	61342.	62001.	68720.
3+ :	161980.	128944.	97444.	86401.	80097.	60289.	84028.	61671.	38753.	30886.	22212.	45547.	54135.	49996.
4+ :	123893.	121320.	93959.	76288.	62279.	52612.	37931.	55050.	33797.	19794.	12396.	13723.	37567.	41734.

Table 22:

4T Herring Fall Spawners :Population (1000's)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	83336.	307503.	63072.	39105.	89560.	110386.	152103.	77534.	244073.	154298.	143867.	213897.	127370.	112810.
3 :	105658.	63809.	246615.	50104.	27781.	73235.	109384.	124351.	62125.	197211.	125154.	117696.	174944.	104245.
4 :	273078.	56813.	47552.	198931.	36514.	20761.	59689.	86847.	84520.	45274.	133907.	94079.	87883.	138870.
5 :	98107.	140391.	32506.	34875.	148260.	26199.	15284.	41752.	46349.	38248.	28612.	82124.	59306.	50678.
6 :	164112.	48698.	69169.	19514.	23421.	98430.	16593.	9278.	21366.	13606.	11757.	18477.	43874.	38773.
7 :	171867.	80797.	21275.	38856.	12558.	12894.	52602.	10348.	4020.	7689.	4118.	7467.	10548.	25415.
8 :	215695.	62625.	40613.	9371.	23097.	7317.	6524.	23040.	5335.	1247.	2819.	2562.	4228.	6488.
9 :	101845.	74789.	27843.	22660.	5427.	14414.	4195.	3369.	6350.	1612.	485.	1500.	1291.	1808.
10 :	63080.	31982.	40240.	16150.	13877.	2475.	8388.	2179.	1330.	650.	607.	218.	692.	507.
11+:	536090.	204421.	117768.	107401.	79502.	59184.	42904.	32233.	17687.	6066.	2670.	1898.	1300.	527.
2+ :	1812868.	1071828.	706654.	536967.	459997.	425296.	467666.	410931.	493155.	465901.	453996.	539919.	513437.	377246.

Table 23:

4T Herring Fall Spawners :Fishing Mortality

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	0.067	0.020	0.030	0.142	0.001	0.000	0.001	0.021	0.013	0.009	0.000	0.001	0.000	0.000
3 :	0.420	0.094	0.014	0.116	0.091	0.004	0.030	0.186	0.116	0.187	0.085	0.092	0.030	0.015
4 :	0.465	0.358	0.110	0.094	0.132	0.106	0.157	0.428	0.593	0.259	0.289	0.261	0.351	0.250
5 :	0.500	0.508	0.310	0.198	0.210	0.257	0.299	0.470	1.026	0.980	0.237	0.382	0.225	0.500
6 :	0.509	0.628	0.377	0.241	0.397	0.427	0.272	0.636	0.822	0.995	0.254	0.361	0.391	0.425
7 :	0.810	0.488	0.620	0.320	0.340	0.481	0.626	0.463	0.971	0.804	0.274	0.369	0.286	0.315
8 :	0.859	0.611	0.384	0.346	0.272	0.356	0.461	1.089	0.996	0.744	0.430	0.485	0.649	0.265
9 :	0.958	0.420	0.345	0.290	0.585	0.341	0.455	0.729	2.079	0.778	0.598	0.575	0.736	0.250
10 :	0.763	0.500	0.300	0.308	0.346	0.437	0.455	0.600	0.850	0.700	0.200	0.200	0.200	0.250
11+:	0.600	0.500	0.150	0.200	0.350	0.400	0.550	0.800	1.000	0.700	0.400	0.100	0.300	0.250

Table 24:

4T Herring Fall Spawners :Population Biomass (tonnes)

YEAR :	71	72	73	74	75	76	77	78	79	80	81	82	83	84
AGE :														
2 :	3333.	12300.	2523.	1838.	3582.	3864.	18100.	9227.	29045.	18361.	17120.	25454.	15157.	13424.
3 :	9826.	3382.	24661.	6313.	3195.	8129.	19361.	22010.	10996.	34906.	22152.	20832.	30965.	18451.
4 :	38777.	9545.	8084.	37797.	6171.	3820.	14624.	21278.	20707.	11092.	32807.	23049.	21531.	34023.
5 :	18542.	27236.	6696.	8196.	31876.	5685.	4325.	11816.	13117.	10824.	8097.	23241.	16784.	14342.
6 :	21170.	11590.	16739.	4976.	5808.	24903.	5194.	2904.	6687.	4259.	3680.	5783.	14359.	12136.
7 :	40217.	20442.	5723.	10996.	3416.	3559.	17780.	3498.	1359.	2599.	1392.	2524.	3565.	8590.
8 :	53492.	16408.	11859.	2943.	6652.	2071.	2342.	8271.	1915.	448.	1012.	920.	1518.	2329.
9 :	26887.	20716.	8214.	7410.	1704.	4324.	1594.	1280.	2413.	613.	184.	570.	491.	687.
10 :	17158.	9179.	12595.	5346.	4510.	799.	3053.	793.	484.	237.	221.	79.	252.	184.
11+:	159219.	63779.	40277.	38020.	28780.	20655.	16947.	12732.	6986.	2396.	1055.	750.	514.	208.
2+:	388622.	194577.	137371.	123834.	95694.	77809.	103320.	93808.	93710.	85735.	87721.	103202.	105135.	104374.
3+:	385289.	182277.	134848.	121996.	92112.	73945.	85220.	84582.	64665.	67373.	70600.	77749.	89978.	90950.
4+:	375463.	178895.	110186.	115683.	88917.	65816.	65859.	62572.	53669.	32467.	48448.	56916.	59013.	72500.

Table 25: Spring Spawner Projections.

4T Herring Spring Spawners :Catch-at-age (1000's)

YEAR :	85	86	87	88	89
AGE :					
2 :	197.	222.	222.	222.	222.
3 :	8942.	10665.	10632.	10632.	10632.
4 :	7503.	16436.	16090.	16085.	16085.
5 :	9705.	6020.	9941.	9759.	9756.
6 :	5556.	3893.	1821.	3015.	2960.
7 :	795.	3250.	1861.	872.	1445.
8 :	110.	411.	1410.	809.	379.
9 :	46.	74.	237.	815.	468.
10 :	65.	41.	58.	186.	638.
11 :	121.	59.	32.	45.	145.
2+ :	33040.	41071.	42302.	42440.	42729.
3+ :	32843.	40848.	42081.	42218.	42508.
4+ :	23901.	30184.	31449.	31586.	31876.
5+ :	16398.	13748.	15359.	15501.	15791.

4T Herring Spring Spawners :Catch Biomass (tonnes)

YEAR :	85	86	87	88	89
AGE :					
2 :	26.	30.	29.	29.	29.
3 :	1538.	1834.	1829.	1829.	1829.
4 :	1598.	3501.	3427.	3426.	3426.
5 :	2397.	1487.	2456.	2410.	2410.
6 :	1595.	1117.	522.	865.	849.
7 :	231.	946.	541.	254.	420.
8 :	34.	128.	437.	251.	118.
9 :	16.	26.	83.	284.	163.
10 :	21.	13.	19.	60.	207.
11 :	43.	21.	12.	16.	52.
2+ :	7500.	9102.	9354.	9425.	9503.
3+ :	7474.	9073.	9325.	9395.	9474.
4+ :	5936.	7238.	7496.	7567.	7645.
5+ :	4338.	3738.	4069.	4140.	4219.

4T Herring Spring Spawners :Population (1000's)

YEAR :	85	86	87	88	89
AGE :					
2 :	104090.	104090.	104090.	104090.	104090.
3 :	85085.	85043.	85017.	85017.	85017.
4 :	35799.	61601.	60471.	60452.	60452.
5 :	46309.	22561.	37363.	36677.	36666.
6 :	49875.	29185.	13684.	22662.	22246.
7 :	10290.	35827.	20567.	9643.	15969.
8 :	2372.	7708.	26488.	15206.	7129.
9 :	1305.	1843.	5943.	20424.	11724.
10 :	1868.	1027.	1443.	4652.	15986.
11 :	3469.	1470.	804.	1129.	3641.
2+ :	340462.	350356.	355869.	359952.	362922.
3+ :	236372.	246266.	251779.	255862.	258832.
4+ :	151287.	161222.	166762.	170844.	173814.
5+ :	115488.	99622.	106291.	110392.	113362.

4T Herring Spring Spawners :Population Biomass (tonnes)

YEAR :	85	86	87	88	89
AGE :					
2 :	13844.	13844.	13844.	13844.	13844.
3 :	14635.	14627.	14623.	14623.	14623.
4 :	7625.	13121.	12880.	12876.	12876.
5 :	11438.	5573.	9229.	9059.	9057.
6 :	14314.	8376.	3927.	6504.	6385.
7 :	2994.	10426.	5985.	2806.	4647.
8 :	735.	2389.	8211.	4714.	2210.
9 :	454.	641.	2068.	7107.	4080.
10 :	605.	333.	467.	1507.	5179.
11 :	1245.	528.	289.	405.	1307.
2+ :	67891.	69858.	71524.	73446.	74208.
3+ :	54047.	56014.	57680.	59602.	60364.
4+ :	39412.	41387.	43057.	44979.	45741.
5+ :	31787.	28266.	30176.	32103.	32865.

Table 26: Fall Spawner Projections.

4T Herring Fall Spawners :Catch-at-age (1000's)

YEAR :	85	86	87	88	89
AGE :					
2 :	7.	4.	4.	4.	4.
3 :	1194.	673.	701.	701.	701.
4 :	16290.	9048.	9484.	9484.	9484.
5 :	30781.	13153.	13296.	13367.	13367.
6 :	7678.	9267.	7070.	6855.	6891.
7 :	4923.	2098.	4544.	3325.	3223.
8 :	3098.	1617.	1247.	2591.	1896.
9 :	790.	1171.	1111.	822.	1707.
10 :	223.	319.	860.	783.	579.
11 :	63.	90.	234.	606.	552.
2+ :	65048.	37439.	38552.	38537.	38404.
3+ :	65041.	37435.	38548.	38533.	38400.
4+ :	63847.	36763.	37847.	37832.	37699.
5+ :	47556.	27715.	28362.	28347.	28215.

4T Herring Fall Spawners :Catch Biomass (tonnes)

YEAR :	85	86	87	88	89
AGE :					
2 :	1.	0.	0.	0.	0.
3 :	211.	119.	124.	124.	124.
4 :	3991.	2217.	2324.	2324.	2324.
5 :	8711.	3722.	3763.	3783.	3783.
6 :	2403.	2901.	2213.	2146.	2157.
7 :	1664.	709.	1536.	1124.	1090.
8 :	1112.	580.	448.	930.	681.
9 :	300.	445.	422.	312.	649.
10 :	81.	116.	313.	285.	211.
11 :	25.	36.	93.	239.	218.
2+ :	18500.	10845.	11235.	11267.	11235.
3+ :	18499.	10845.	11235.	11267.	11235.
4+ :	18288.	10726.	11111.	11142.	11111.
5+ :	14297.	8509.	8787.	8819.	8787.

4T Herring Fall Spawners :Population (1000's)

YEAR :	85	86	87	88	89
AGE :					
2 :	112810.	112810.	112810.	112810.	112810.
3 :	92361.	92355.	92357.	92357.	92357.
4 :	84078.	74540.	74936.	74938.	74938.
5 :	88547.	54180.	52528.	52807.	52808.
6 :	25166.	44911.	32862.	31860.	32029.
7 :	20754.	13715.	28494.	20849.	20213.
8 :	15185.	12567.	9295.	19311.	14130.
9 :	4075.	9646.	8776.	6491.	13486.
10 :	1153.	2626.	6797.	6184.	4574.
11 :	323.	743.	1851.	4790.	4358.
2+ :	444453.	418092.	420705.	422397.	421704.
3+ :	331643.	305282.	307895.	309587.	308894.
4+ :	239282.	212927.	215538.	217230.	216537.
5+ :	155204.	138387.	140602.	142292.	141599.

4T Herring Fall Spawners :Population Biomass (tonnes)

YEAR :	85	86	87	88	89
AGE :					
2 :	13424.	13424.	13424.	13424.	13424.
3 :	16348.	16347.	16347.	16347.	16347.
4 :	20599.	18262.	18359.	18360.	18360.
5 :	25059.	15333.	14865.	14944.	14945.
6 :	7877.	14057.	10286.	9972.	10025.
7 :	7015.	4636.	9631.	7047.	6832.
8 :	5452.	4511.	3337.	6933.	5073.
9 :	1549.	3665.	3335.	2467.	5125.
10 :	420.	956.	2474.	2251.	1665.
11 :	128.	293.	731.	1892.	1721.
2+ :	97870.	91485.	92790.	93637.	93517.
3+ :	84445.	78061.	79365.	80213.	80093.
4+ :	68097.	61714.	63018.	63866.	63746.
5+ :	47498.	43452.	44659.	45506.	45386.

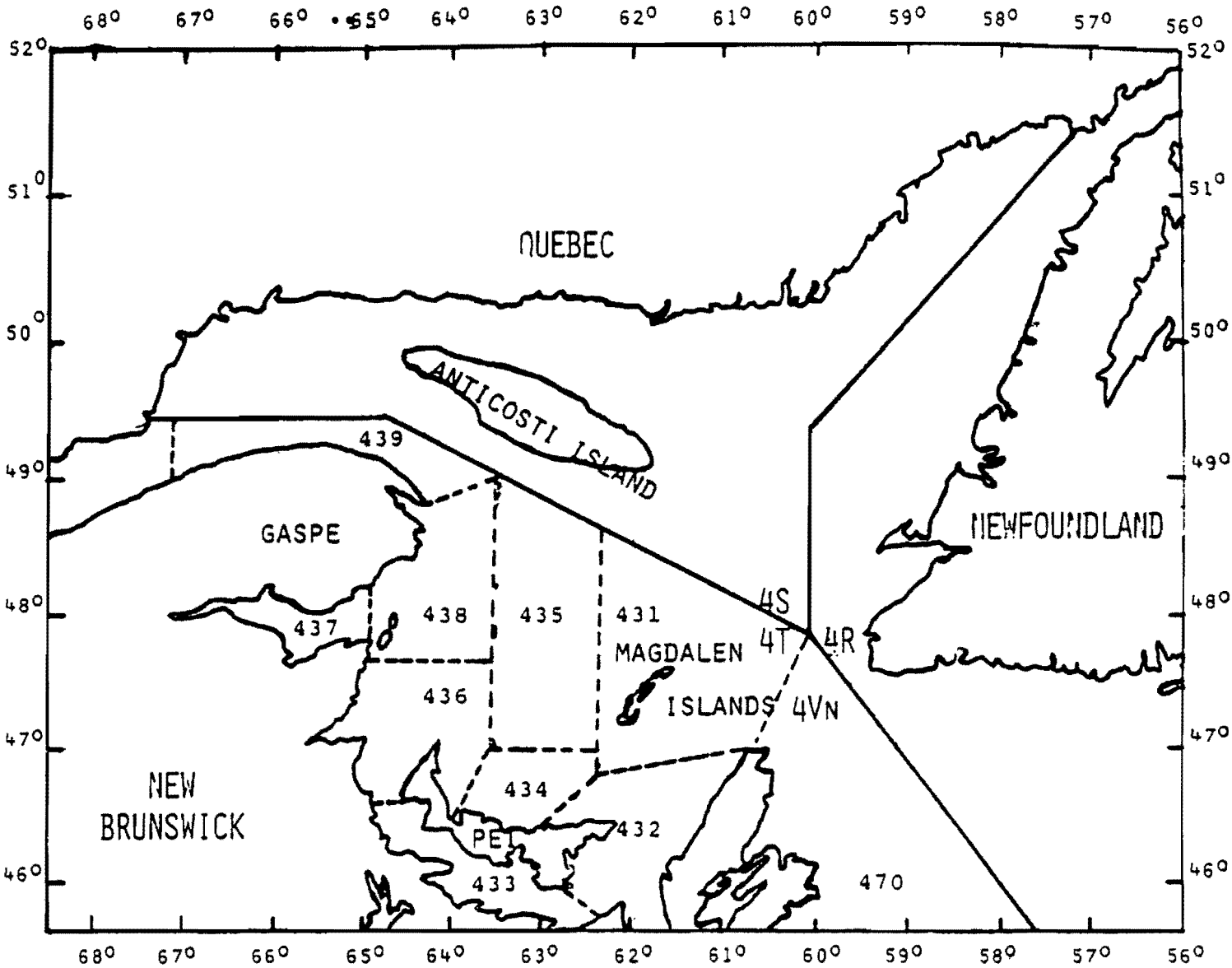

Fig. 1. Map showing statistical unit areas for the Southern Gulf of St. Lawrence.

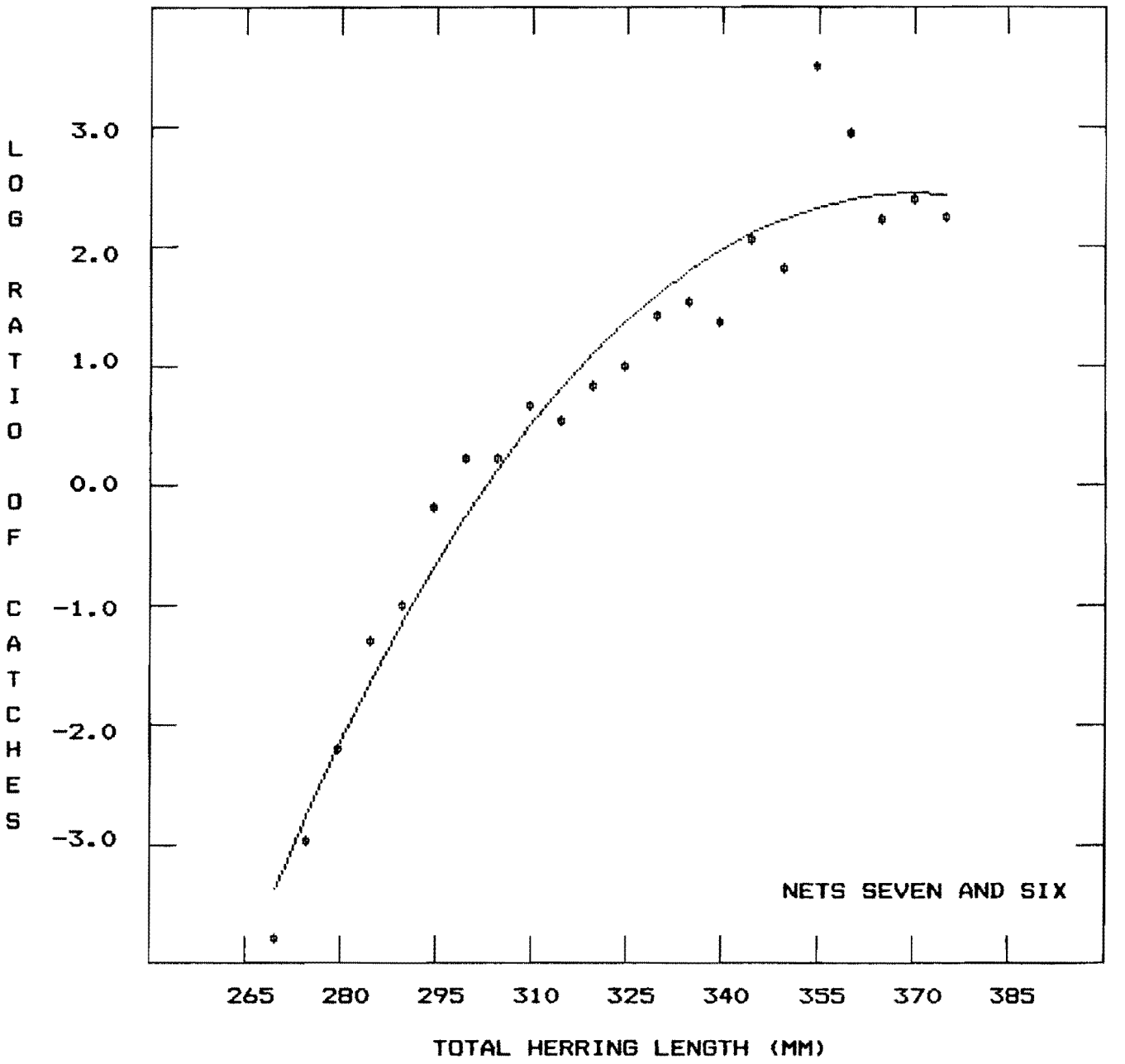

Figure 2: Typical regression between herring length and the log ratio of catches from two mesh sizes.

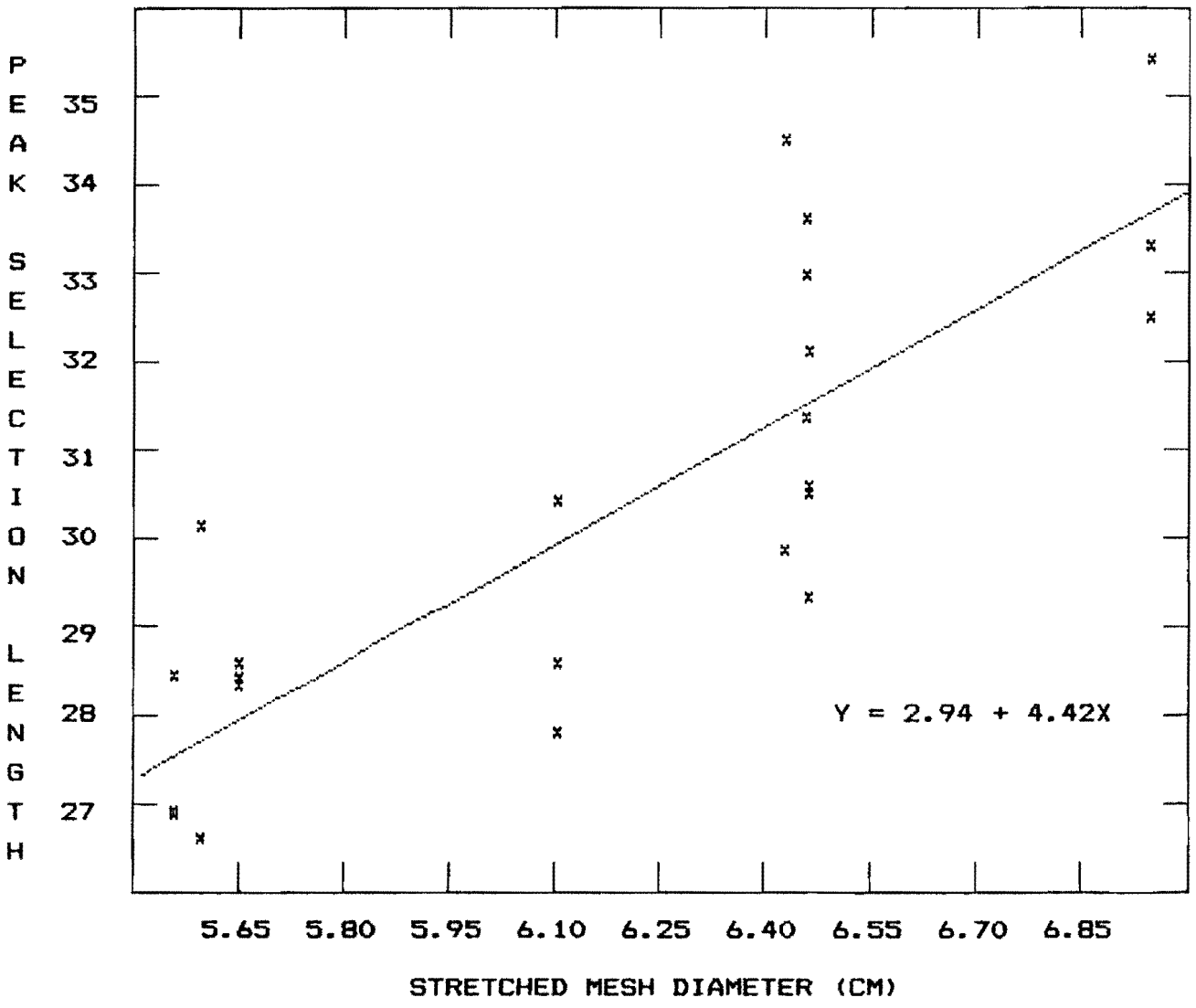

Figure 3: Relationship between mesh diameter and peak selection length.

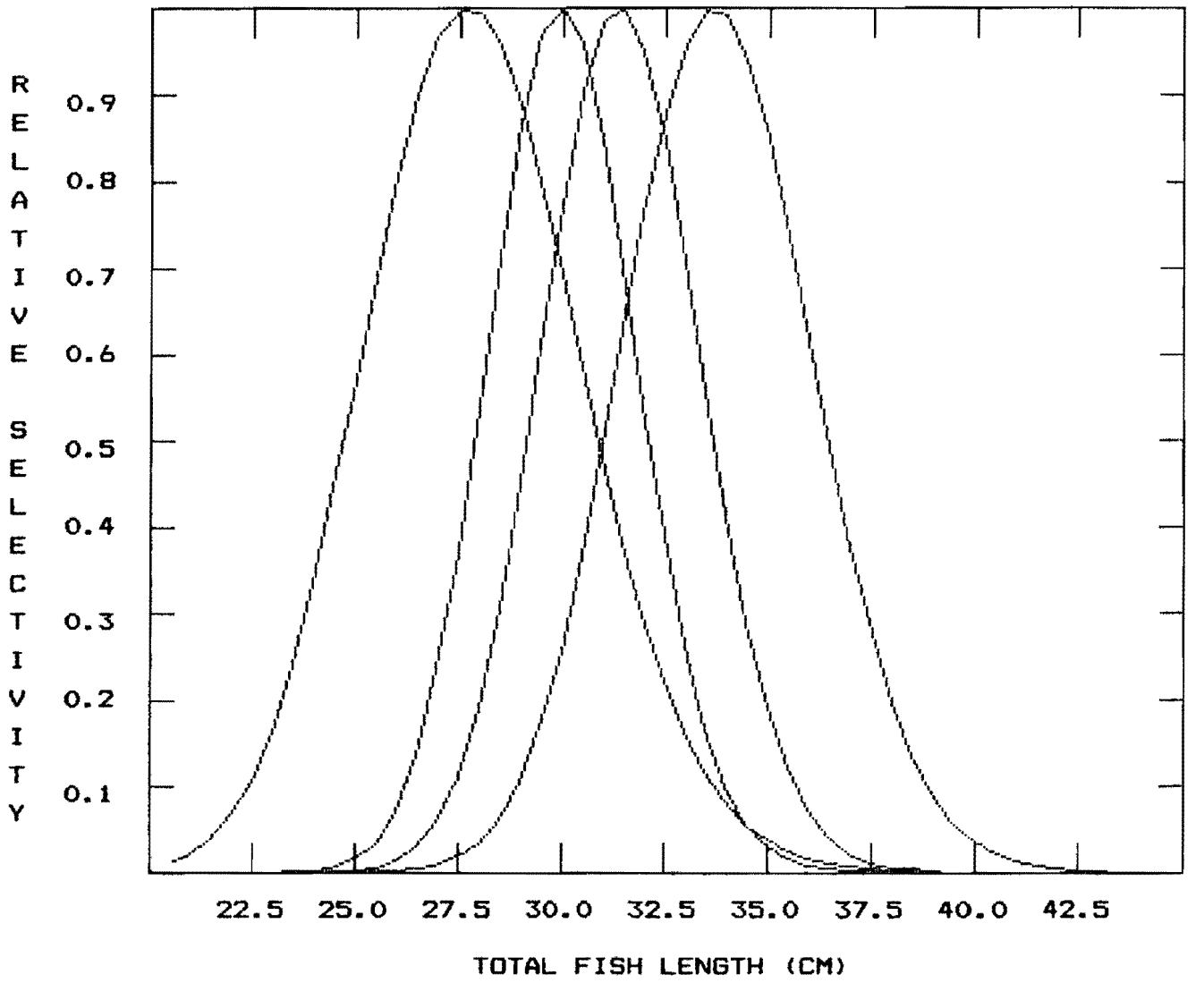

Figure 4: Mean selection curves for nets with nominal stretched mesh diameters of 2⅛, 2¼, 2 5/8, and 2 3/4.

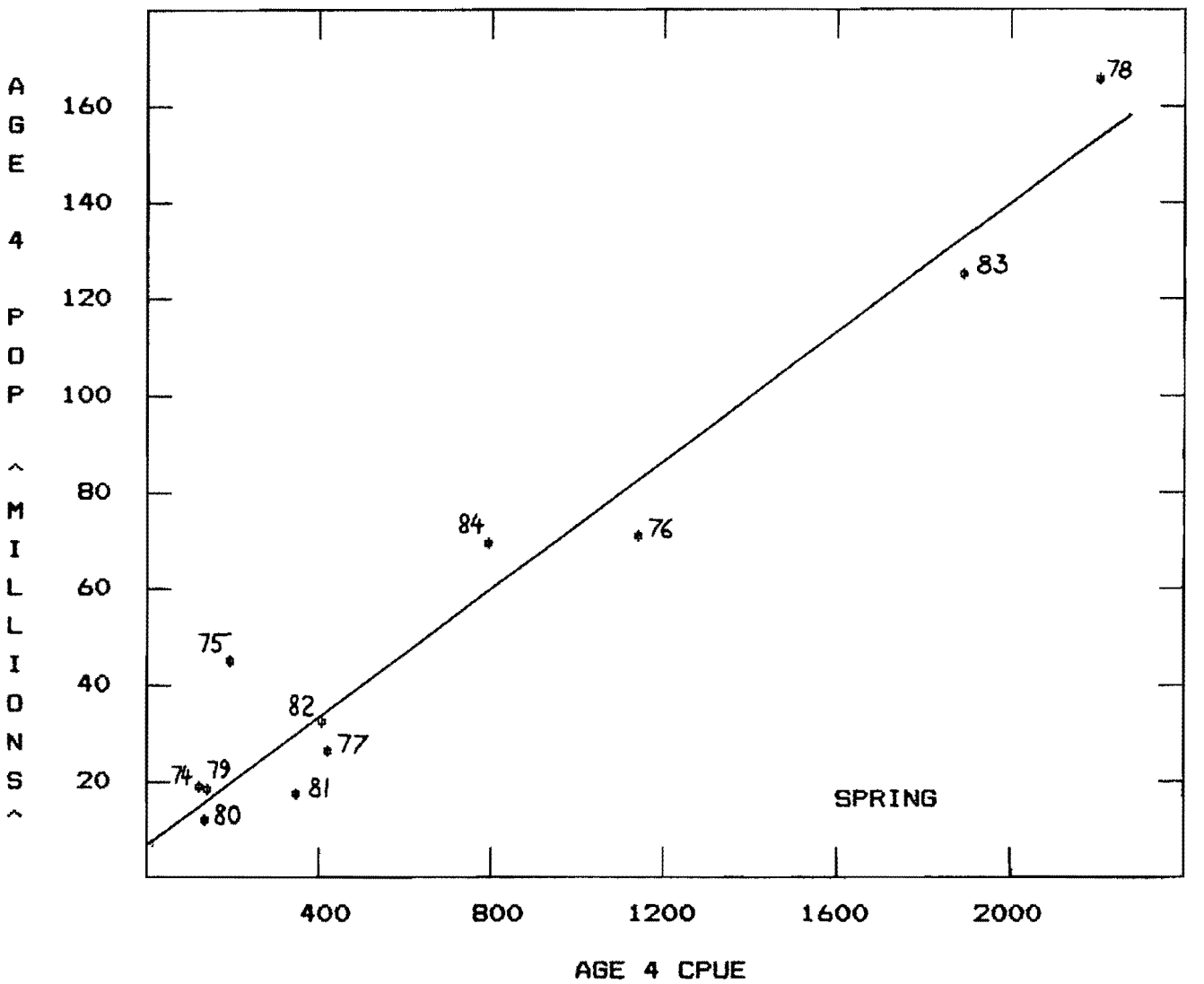

Figure 5: Relationship between estimated population of four year olds and gillnet catch of four year old spring spawners per unit spring gillnet effort. $F_t = 0.2$; $R^2 = 0.95$.

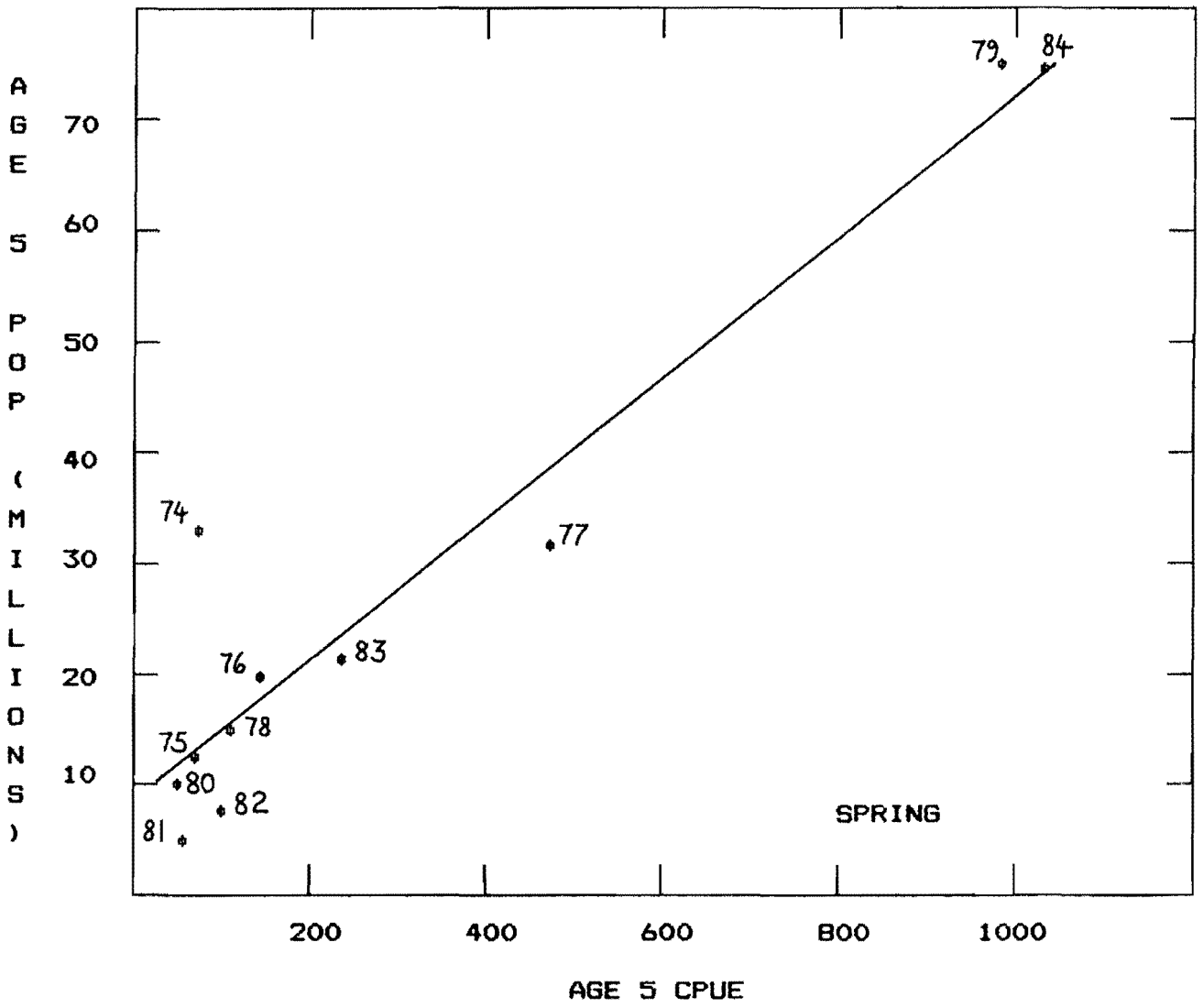

Figure 6: Relationship between estimated population of five year olds and gillnet catch of five year old spring spawners per unit spring gillnet effort. $F_t = 0.2$; $R^2 = 0.90$.

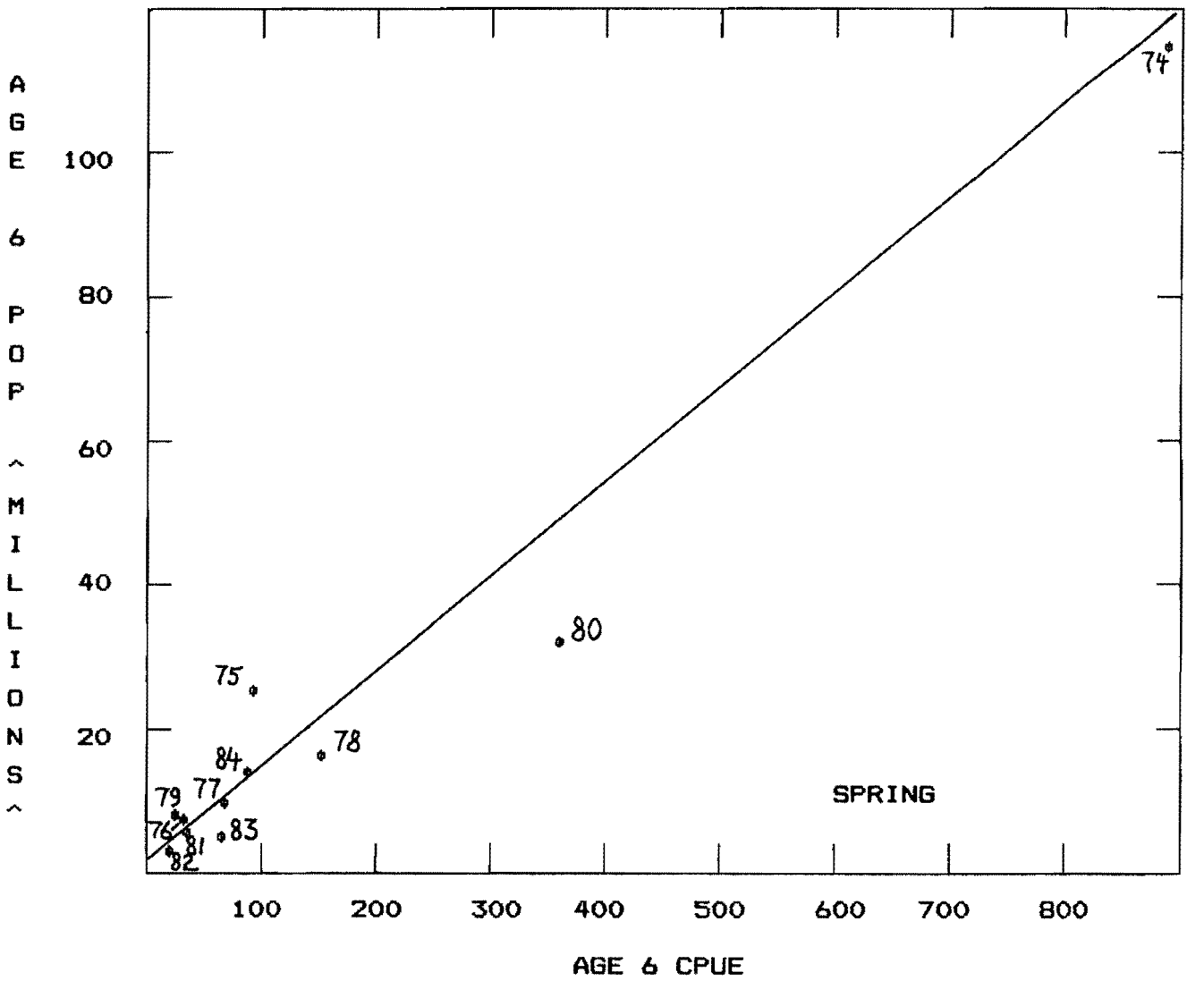

Figure 7: Relationship between estimated population of six year olds and gillnet catch of six year olds spring spawners per unit spring gillnet effort. $F_t = 0.2$; $R^2 = 0.96$.

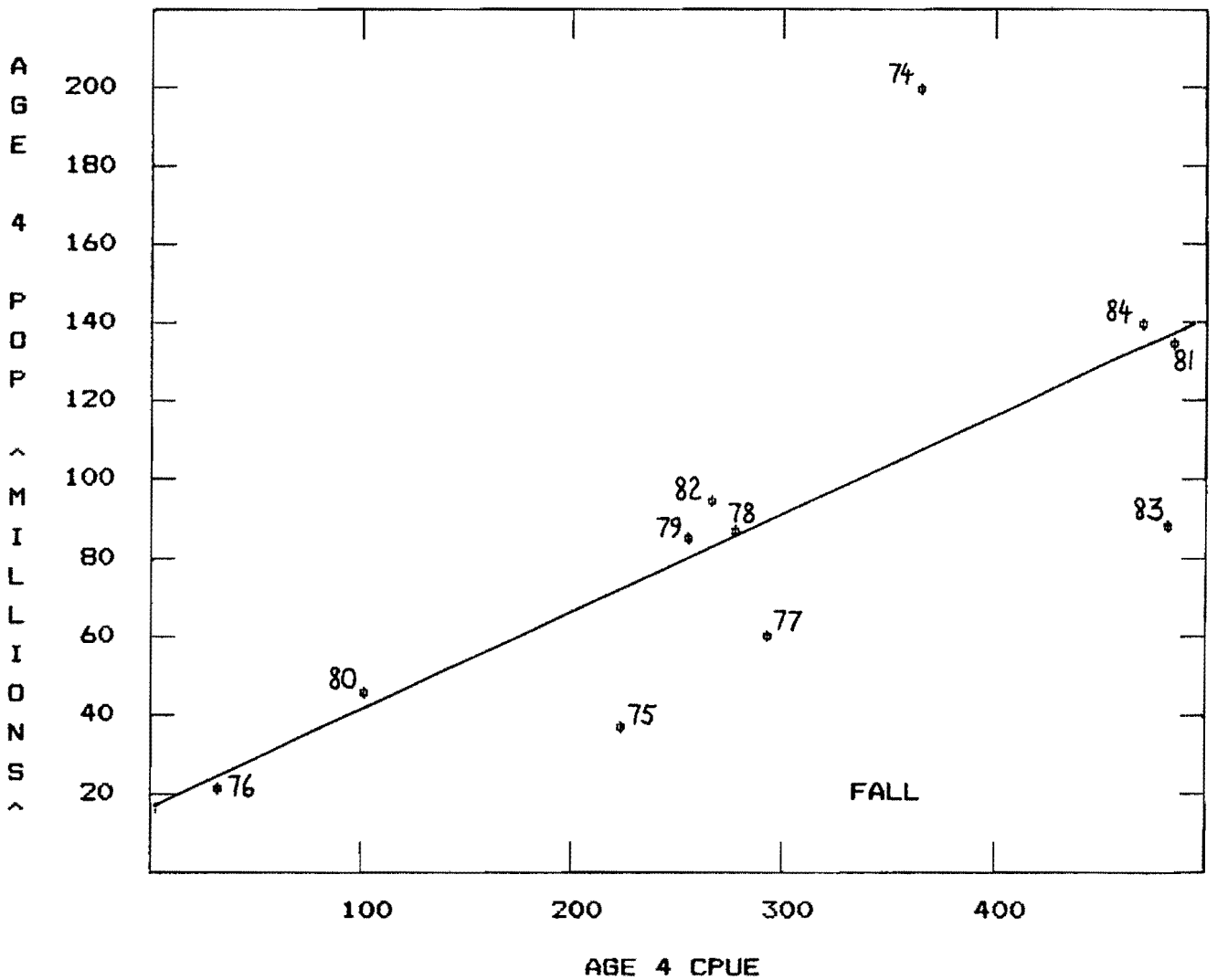

Figure 8: Relationship between estimated population of four year olds and gillnet catch of four year old fall spawners per unit fall gillnet effort. $F_t = 0.5$; $R^2 = 0.51$.

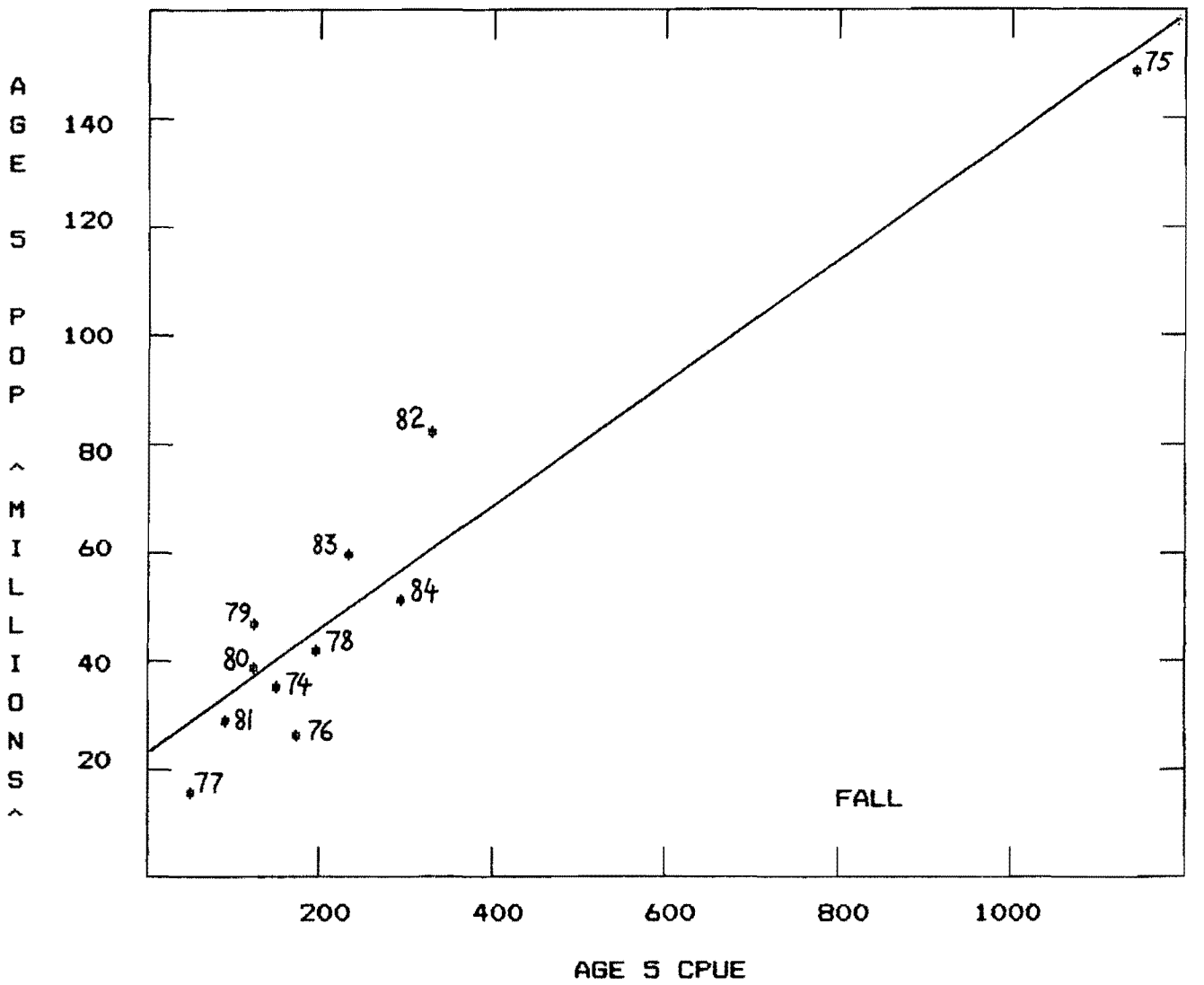

Figure 9: Relationship between estimated population of five year olds and gillnet catch of five year old fall spawners per unit fall gillnet effort. $F_t = 0.5$; $R^2 = 0.91$.

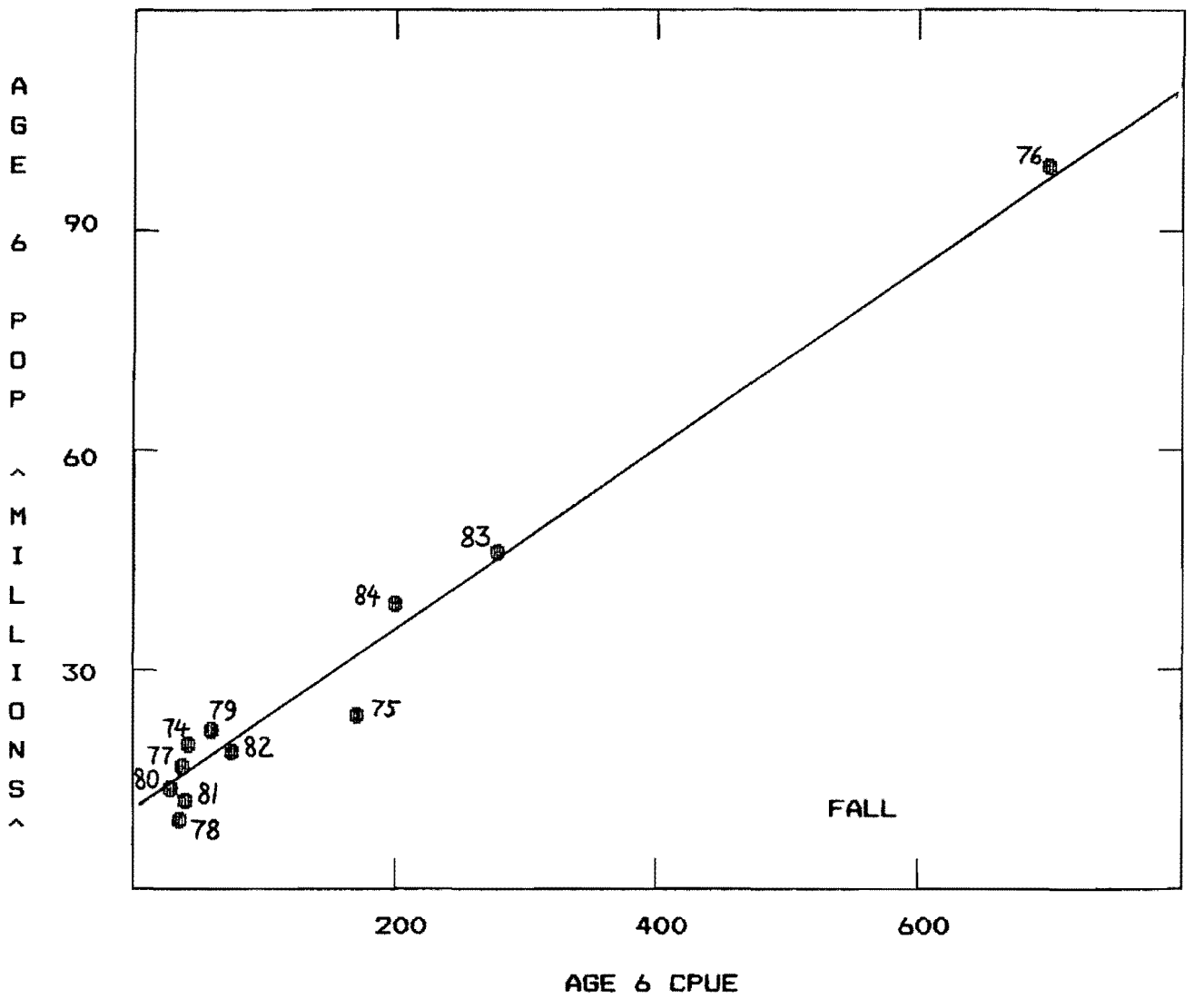

Figure 10: Relationship between estimated population of six year olds and gillnet catch of six year old fall spawners per unit fall gillnet effort. $F_t = 0.5$; $R^2 = 0.98$.

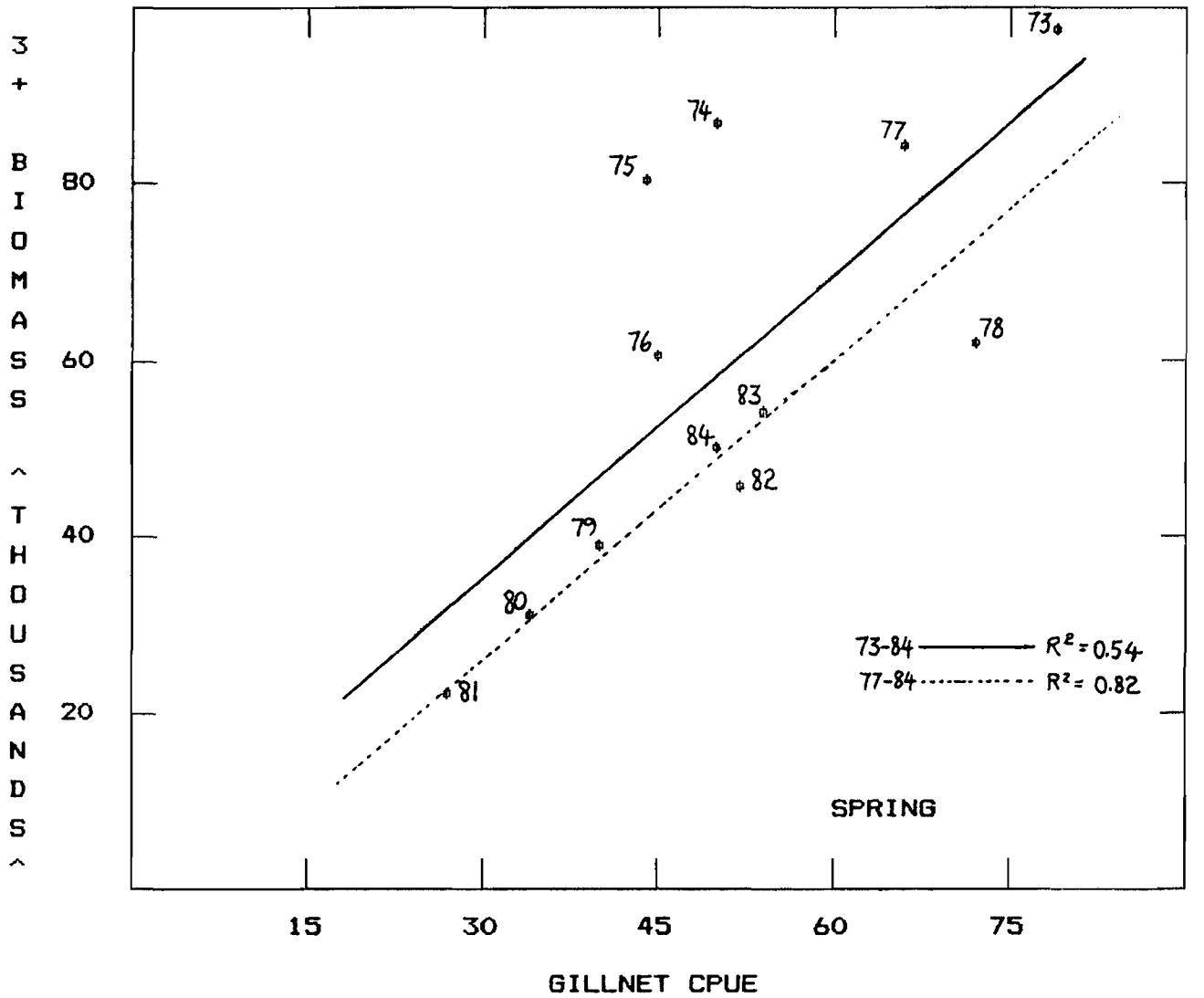

Figure 11: Relationship between spring gillnet catch rates and 3+ biomass of spring spawners. $F_t = 0.2$.

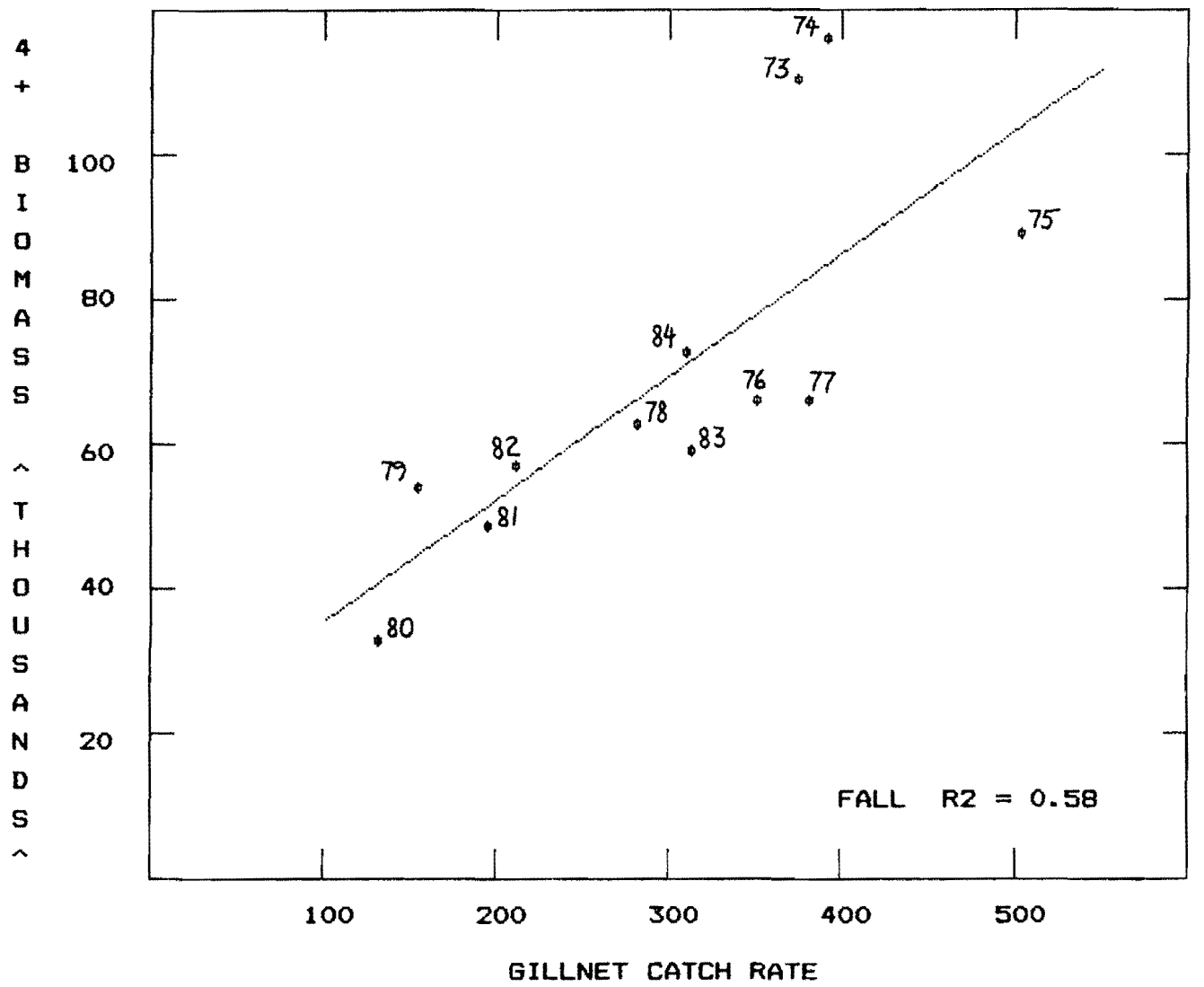

Figure 12: Relationship between fall gillnet catch rates and 4+ biomass of fall spawners. $F_t = 0.5$.