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1986 Stock Assessment Of American Plaice

In NAFO Division 4T

by

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ABSTRACT

Data from the research vessel surveys and commercial catch data for 1985 were analysed. Landings for 1985, althought slightly lower than 1984, remain at the levels reached in the late 1970's. Catch rates have declined considerably since 1979. A sequential population analysis was not attempted at this time, due to some problems with the commercial data. Fishing mortality, estimated from the research vessel, is at a higher level than the $F_{0.1}$.

RESUME

L'information relevé des croissières de recherche, ainsi que les données sur les prises commerciales fusent analysés. Les débarquements de 1985, étant légèrements inférieures à ceux de 1984, restent aux niveaux atteints à la fin des années 1970. Les taux de capture ont subit une baisse considérable depuis 1979. Une analyse séquentielle de population n'a pas été entreprise, suite à des problèmes avec les données commerciales. La mortalité due à la pêche, estimée à partir des données de croissiéres de recherche, est à un niveau superieur au $F_{0.1}$.

INTRODUCTION

The American plaice (Hippoglossoides platessoides) supports the most important commercial flatfish fishery in the Gulf of St. Lawrence. It represents 78% of the 1985 landing of 17,327 tons. The other components of the NAFO Division 4RST flatfish fishery are reported in Table 1. Landings are broken down by NAFO's Division and region in Table 2.

The American plaice fishery for NAFO Division 4T has been traditionally a by-catch fishery from the southern Gulf of St. Lawrence cod fishery. However, in the past two years plaice landings from the plaice directed fishery, as defined by the main species on a purchase slip, have exceeded those from the cod directed fishery, which could indicate a change of direction towards plaice (Figure 1). This would coincide with the increase in price for plaice. Landings by month and by gear for 1985 are presented in Table 3. Landings for the months of October, November and December have been affected by an unprecedented closure of the plaice directed fishery for vessels under 65 feet using mobile gears, and a 10% restriction on by-catch from other fisheries. These restrictions were implemented after a 8,100 tons allocation was reached. With the early fulfillment of this allocation, there were some concerns over the problem of misreporting other flounders against the 4T American plaice quota, for 1985. Although, it cannot be verified at this time, this would seem unlikely, considering the relative stability in the species composition of the overall flatfish landings in NAFO Divison 4RST over the past 3 years (Table 4).

Nominal Landings

The 1985 provisional landings for American plaice in NAFO Division 4T is 9,151 tons. Although this is slightly lower than 1984, it remains higher than the average landing over the past 13 years. The historical landing composition by gear is presented in Table 5, and Figure 2. Otter trawlers and Danish seines contributed equally to the 1985 landing with 41% each. The remaining 18% was mostly caught by gillnets and longlines. The estimated total landings are also shown in Table 5. They include 90% of the reported landing from the unspecified flounder category. In 1985, 0.3 ton was reported in that category.

Catch Per Unit Of Effort

Two main fishing categories contribute to the 4T American plaice landings: 1) by-catch from the cod directed fishery, 2) the plaice directed fishery. In past assessments, catch rate indices were derived from catch in hours by Danish seines tonnage class (T.C.) 2, from the plaice directed fishery (Metuzals, 1985). In this assessment, standardized catch rate indices were calculated from both fishing categories, plaice directed and cod directed, using a multiplicative model (Gavaris, 1980). Plaice catch (&10t) and effort (&10 hours) data from otter trawls (OTB-1 and OTB-2) and Danish seines of T.C. 2, 3 and 4, were analysed using the Standard WS software, version 4 in STSC APL. Results from these analysis are shown in Tables 6 and 7 and Figures 3 and 4. The differences between the two indices were difficult to interpret because the two fishing categories were distinguished on the basis of the predominant species in their catches. There is no indication that the above mentioned fishing categories result from two fisheries for which a particular species is sought.

These two fisheries may only differ in the spatiotemporal distribution of plaice and cod in the course of the fishing season, or in the discarding practices. In any case, the uncertainty in the definition of the plaice directed fishery makes the use of these catch rate indices doubtful and therefore will not be used for this assessment.

Landing At Age

The commercial landings at age were calculated for 1985 and recalculated for 1976-1984, for both sexes separately. The recalculation of the 1976-1984 landing matrix was due to the availability of additional sampling data from provincial fishery agencies. The computer programme ALSYSX was used to generate the age length keys. The information pertaining to the generating of these keys is summarized in table 8. In order to be consistent with previous assessments, sexes were combined. The landings at age and percent at age for 1976 to 1985 are shown in tables 9 and 10. A comparison of this new matrix with the one from Metuzals (1985) was done by calculating the ratio of the number at age from each matrix. The results from this comparison are presented in Table 11. The high level of disagreement between these two matrices may be due to the incorporation of the newly acquired data, or/and

the use of different parameters such as the A's and B's from the weight-length equation in the calculation of the new matrix. The use of either matrices was suspended until further investigation.

Average weight at age and estimated landed biomass at age matrices are shown in Table 12.

Discards

Discarding practices for the American plaice fishery have been investigated by several authors over the past two decades. A recent study showed that 39.5% of the total catch weight is discarded at sea (Chouinard and Metuzals, 1985). Discarding, for the most part, is concentrated on plaice under 30 cm in length, and the survival rate of these discarded fish varies from 70% to 0% depending on the time and temperature of exposure (Jean, 1963). The absence of these fish in the port sampling programme represents a major disruption in the data available to evaluate the American plaice stock. The use of discarding estimates in stock assessment calculation is not recommended at this time, due to the limited information available and the unstable nature of discarding practices in this fishery.

Research Vessel Survey

Groundfish research survey was carried out on the E.E. Prince in the fall of 1985. The data was analyzed using the computer programme RVAN (Clay, 1986).

Estimates of population numbers at age are shown in Table 13. Average weight at age were calculated and are shown in Table 14. Two catch rate indices were calculated from the 1970-1985 data: 1) weight per standard tow and, 2) numbers per standard tow. Both these indices indicate a sharp decline from the 1979 levels (Figure 5).

Partial Recruitment

Partial recruitment vectors were calculated for 1984 and 1985 using the RNFS method (Rivard, 1984). The resulting standardized PRs were then averaged indicating full recruitment at age 14 and older. The older ages were adjusted to 1 to obtain a flat-top PR vector.

Yield-Per-Recruit

A Thompson-Bell yield-per-recruit analysis was run using the following parameters:

AGE	PR	WEIGHTS
6	0.010	0.279
7	0.028	0.319
8	0.041	0.381
9	0.091	0.445
10	0.181	0.457
11	0.349	0.453
12	0.493	0.668
13	0.675	0.869
14	1.000	0.975
15	1.000	1.182
16	1.000	1.275
17	1.000	1.288
18	1.000	1.561
19	1.000	1.647
20	1.000	2.164
21	1.000	2.174

The natural mortality was assumed at 0.2. The average weights at age were obtained from the 1985 age length keys (Table 12). Results are shown in Figure 6. The calculated $F_{0.1}$ (0.302) is comparable to the $F_{0.1}$ of 0.32 calculated by Brodie and Pitt (1983) for the Divisions 2J, 3K American plaice stock.

Mortality Estimates

Population estimates at age from research surveys were used to estimate recent mortality rates. Paloheimo Z's were calculated along cohorts for ages 1-19 and the years 81-82, 82-83, 83-84, 84-85 (Table 15). Several negative values were found indicating some strong yearly fluctuations in the survey estimates. Averaging the age by age estimates across all years indicated increasing total mortalities from age 1 to age 13, followed by a decrease to older ages. For the period of full recruitment to the fishery the average total mortality was .60.

A multiplicative analysis of the survey estimates was carried out to obtain a catch curve corrected for year class variation. Two time periods were analyzed, 1976-1980 and 1981-1985. Both catch curves indicated high mortalities on ages 5 to 10, through the pre-recruit phase of their life history. In the 1976-80 period, mortality appeared to be constant for ages 8-19. The slope of the curve indicated a total mortality of .58 (Figure 7). For the 1981-1985 period mortality appeared to be highest for ages 8-13 (Z=.75) and lower for older ages (Z=.53). For ages 8-19, Z was calculated to

be .66 (Figure 8). These apparent high mortalities of young fish may be the result of discarding.

CONCLUSION

In light of the problems uncovered in this paper, an analytical assessment of the 4T American plaice was not possible at this time. Furthermore, the accuracy of the evaluation of this stock is greatly dependent on the quantity and quality of commercial sampling data, discarding information and the incorporation of discard estimates in these analysis.

Research vessel survey remains the most reliable indicator of the status of the 4T American plaice stock. The total mortality estimate, from RV data is in the vicinity of 0.6. Assuming the natural mortality at 0.2, the current fishing mortality, including the mortality resulting from discarding would be 0.40. This mortality is higher than the estimated $F_{0.1} = 0.3$, and considering the declining biomass estimates (since 1979) there is no basis to increase the TAC from 10,000 t.

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Table 1. Flatfish landings (t) in NAFO Division 4RST during 1963-1985.

YEAR	YELLOW TAIL	ATLANT HALIBUT	GREEN HALIBUT	WITCH	WINTER FLOUNDER	PLAICE	UNSPEC FLOUNDER	TOTAL FLATFISH
1963	107	537	0	4250	3165	8470	0	16529
1964	65	615	0	3350	3014	8803	9	15856
1965	53	693	24	3608	4419	11098	5	19900
1966	157	612	365	3712	3136	12720	0	20702
1967	79	459	365	2714	2454	10478	24	16573
1968	12	443	686	3388	551	11911	0	16991
1969	268	506	801	4652	1710	10841	0	18778
1970	59	509	1112	4801	2694	13132	0	22307
1971	40	454	954	3821	2842	11765	0	19876
1972	3	310	681	2001	1911	9724	1373	16003
1973	6	385	756	2224	2384	8007	2426	16188
1974	27	418	1011	3247	1976	11261	999	18939
1975	3	272	1544	2722	2050	10177	3951	20719
1976	37	196	2019	6875	2471	14265	1785	27648
1977	30	150	3961	3039	1358	12665	1995	23198
1978	13	135	6247	4510	1236	12375	1196	25712
1979	69	132	8791	4561	1722	12943	894	29112
1980	46	202	7006	3527	2053	11115	1163	25112
1981	14	95	3176	1912	2013	10210	532	17952
1982	5	90	2269	1282	2339	8074	479	14538
1983	50	173	1577	1030	1799	8268	792	13689
1984	96	82	1747	1276	1515	10725	0	15441
1985	223	173	2388	1724	1850	10984	3	17345
TOTAL	1462	7641	47480	74226	50662	250011	17626	449108
AVERAGE	64	332	2064	3227	2203	10870	766	19526

Table 2. 1985 Flounder Landings (t) all gears combined.

AREA REGION	AMERICAN PLAICE	WITCH	YELLOW TAIL	WINTER FLOUNDER	ATLANTIC HALIBUT	GREENLAND HALIBUT	FLOUNDER UNSPECIFIED
4R							
Quebec	0.2	0.4	/	/	/	0.5	/
Gulf	1034	598	4	686	47	222	/
Scotia	8	4	1	/	4	/	/
Nfld.	/	8	1	/	3	8	/
TOTAL	1042.2	610.4	6	686	54	230.5	0
4S							
Quebec	747.3	140.4	/	0.5	41.3	743	2.4
Gulf	43	/	/	4	3	122	/
Scotia	/	1	/	/	/	/	/
Nfld.	/	2	/	/	/	1	/
TOTAL	790	143.3	0	4.5	44.3	865	2.4
4T							
Quebec	2360.5	386.8	73.4	73	71.1	1288.7	0.3
Gulf	6771	573	144	1086	1	4	/
Scotia	20	10	/	/	3	/	/
Nfld.	/	/	/	/	/	/	/
TOTAL	9151.5	969.8	217.4	1159	75.1	1292.7	0.3
4RST	10,984	1724	223	1850	173	2388	3

Table 3. Nominal Catch (t) of Plaice in NAFO Division 4T 1985.

MONTH	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	TOTAL
OTB1		42	128	97	172	65	157	199	58	0	0	919
OTB2		65	324	485	531	503	660	235	21	17	5	2846
SDN	2	86	747	473	524	583	652	480	206	41	0	3794
LL		0	29	68	123	133	53	17	7	0	0	430
GN		12	230	102	106	208	79	16	2	0	0	755
OTHER		0	31	3	27	80	139	108	15	2	0	406
TOTAL	2	205	1491	1228	1483	1572	1740	1055	309	60	5	9151

Others include: Midwater trawl, purse seine, handline and miscellaneous gear.

Table 4. Species composition of the flatfish landing (t) in NAFO 4RST.

YEAR	TOTAL LANDING	AMERICAN PLAICE	WINTER FLOUNDER	WITCH FLOUNDER	YELLOWTAIL
1985	14 763	74%	13%	12%	2%
1984	13 612	79%	11%	9%	1%
1983	11 147	74%	16%	9%	1%

Table 5. American Plaice Landings (t) in NAFO Division 4T, 1972-1985.

YEAR	GEAR	TRAWL	SEINE	GILLNET	OTHER	TOTAL	ESTIMATED* TOTAL
1972		5135	2315	286	558	8294	9375
1973		3558	2743	241	363	6905	8154
1974		4131	3661	250	443	8485	9027
1975		3989	3878	217	359	8443	10661
1976		6962	3376	225	630	11193	11794
1977		4634	4004	242	350	9230	10277
1978		4540	3489	379	623	9031	9719
1979		4523	3724	750	999	9996	10753
1980		3887	3472	726	207	8292	8975
1981		2623	3570	1084	557	7834	7940
1982		1459	4124	805	154	6542	6852
1983		1402	4095	494	103	6094	6806
1984		3176	3721	1923	611	9432	9473
1985		3765	3795	757	835	9151	9151
TOTAL		53784	49967	8379	6792	118922	128957
AVERAGE		3842	3569	599	485	8494	9211

* Including 90% from the unspecified flounder category.

Table 6a. Results from the regression of the multiplicative model, for the by catch fishery. Category type: 1; gears, 2; main species, 3; months, 4; years.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R 791
MULTIPLE R SQUARED 626

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.116E0003	6.116E0003	
REGRESSION	37	3.574E0002	9.660E0000	28.011
TYPE 1	7	2.296E0002	3.280E0001	95.101
TYPE 2	0	0.000E0000	1.000E0000	2.900
TYPE 3	11	2.953E0001	2.684E0000	7.783
TYPE 4	19	5.677E0001	2.988E0000	8.663
RESIDUALS	618	2.131E0002	3.449E0001	
TOTAL	656	6.686E0003		

Table 6b. Regression coefficients from the multiplicative model. Category code. Category type 1: 112, 113, 114 = OTB-1 Tonnage class 2, 3 and 4: 122, 123, 145 = OTB-2 TC 2, 3 and 4; 212, 213 = Danish seines, TC 2 and 3. Category type 2: 1 = cod; 10 - plaice. Category type 3; month and Category type 4; years.

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	* 112	INTERCEPT	4.392	0.288	656
2	1				
3	1				
4	66				
1	113	1	0.702	0.069	176
	114	2	1.432	0.106	58
	122	3	1.608	0.349	3
	123	4	1.257	0.100	52
	124	5	1.622	0.138	27
	212	6	1.648	0.078	115
	213	7	1.652	0.083	97
3	2	8	0.262	0.626	1
	3	9	0.611	0.628	1
	4	10	1.063	0.223	50
	5	11	0.709	0.217	95
	6	12	0.537	0.223	74
	7	13	0.411	0.226	68
	8	14	0.604	0.226	70
	9	15	0.790	0.226	68
	10	16	0.882	0.224	81
	11	17	0.944	0.220	84
	12	18	0.994	0.220	55
4	67	19	-0.307	0.210	27
	68	20	0.012	0.211	27
	69	21	-0.177	0.209	30
	70	22	-0.250	0.203	35
	71	23	-0.374	0.200	36
	72	24	-0.527	0.206	30
	73	25	-0.496	0.206	30
	74	26	-0.441	0.217	23
	75	27	-0.805	0.233	20
	76	28	-0.366	0.224	20
	77	29	-0.022	0.208	31
	78	30	-0.069	0.205	35
	79	31	-0.236	0.197	51
	80	32	-0.258	0.199	47
	81	33	-0.469	0.199	48
	82	34	-0.965	0.200	43
	83	35	-0.708	0.202	39
	84	36	-0.791	0.206	34
	85	37	-0.980	0.203	38

Table 6c. Predicted catch rate from the multiplicative model.

PREDICTED RELATIVE POWER

YEAR	TOTAL CATCH	PROP.	RELATIVE POWER MEAN	RELATIVE POWER S.E.	EFFORT
66	11780	0.221	1.000	0.000	11780
67	9351	0.291	0.856	0.178	10928
68	9568	0.298	1.177	0.245	8133
69	8192	0.268	0.975	0.202	8406
70	9300	0.272	0.906	0.182	10261
71	9513	0.288	0.801	0.159	11873
72	8294	0.286	0.687	0.140	12077
73	7047	0.216	0.709	0.144	9944
74	8485	0.149	0.747	0.160	11356
75	8443	0.130	0.518	0.114	16296
76	11193	0.085	0.803	0.178	13931
77	9230	0.286	1.138	0.235	8111
78	9031	0.319	1.086	0.221	8314
79	9996	0.307	0.921	0.180	10858
80	8292	0.341	0.900	0.177	9215
81	7834	0.283	0.729	0.143	10750
82	6542	0.265	0.444	0.088	14745
83	6094	0.279	0.574	0.115	10625
84	9432	0.088	0.528	0.108	17872
85	9151	0.148	0.437	0.088	20934

AVERAGE C.V. FOR THE MEAN: .194

Table 7a. Results from the regression of the multiplicative model for the plaice directed fishery. Category type: 1; gears, 2; mean species, 3; months, 4; years.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R 852
MULTIPLE R SQUARED 725

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.242E000	6.242E0003	
REGRESSION	38	8.185E000	2.154E0001	60.841
TYPE 1	7	2.241E000	3.201E0001	90.403
TYPE 2	1	2.376E000	2.376E0002	671.110
TYPE 3	11	3.422E000	3.111E0000	8.788
TYPE 4	19	5.685E000	2.992E0000	8.452
RESIDUALS	875	3.098E0002	3.541E0001	
TOTAL	914	7.371E0003		

Table 7b. Regression coefficients from the multiplicative model. Category code. Category type 1: 112, 113, 114 = OTB-1 Tonnage class 2, 3 and 4: 122, 123, 134 = OTB-2, 3 and 4; 212, 213 = Danish seines, TC 2 and 3. Category type 2: 1 = cod; 10 = plaice. Category type 3; month and category type 3; years.

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	112	INTERCEPT	4.220	0.287	914
2	1				
3	1				
4	66				
1	113	1	0.737	0.065	207
	114	2	1.374	0.100	63
	122	3	0.942	0.178	13
	123	4	1.305	0.085	84
	124	5	1.557	0.127	32
	212	6	1.464	0.069	197
	213	7	1.466	0.071	173
2	10	8	1.330	0.051	252
3	2	9	0.255	0.634	1
	3	10	0.674	0.636	1
	4	11	1.108	0.221	72
	5	12	0.668	0.217	123
	6	13	0.576	0.221	104
	7	14	0.451	0.223	97
	8	15	0.607	0.223	103
	9	16	0.678	0.222	113
	10	17	0.802	0.222	119
	11	18	0.872	0.219	111
	12	19	1.036	0.221	61
4	67	20	-0.414	0.211	27
	68	21	-0.119	0.212	27
	69	22	-0.353	0.209	31
	70	23	-0.357	0.204	35
	71	24	-0.480	0.202	36
	72	25	-0.638	0.205	32
	73	26	-0.646	0.206	31
	74	27	-0.874	0.199	50
	75	28	-0.971	0.221	21
	76	29	-0.486	0.224	20
	77	30	-0.290	0.196	65
	78	31	-0.248	0.196	63
	79	32	-0.328	0.192	85
	80	33	-0.322	0.193	71
	81	34	-0.447	0.193	72
	82	35	-0.919	0.195	58
	83	36	-0.769	0.196	55
	84	37	-0.766	0.196	57
	85	38	-0.826	0.194	66

Table 7c. Predicted catch rate from the multiplicative model.

STANDARDS USED VARIABLE NUMBERS: 112 1 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	CATCH RATE S.E.	EFFORT
66	11780	0.221	0.017	0.005	699945
67	9351	0.291	0.011	0.003	831007
68	9568	0.298	0.015	0.004	632952
69	8192	0.270	0.012	0.003	684476
70	9300	0.272	0.012	0.003	778774
71	9513	0.288	0.011	0.002	900682
72	8294	0.293	0.009	0.002	922233
73	7047	0.218	0.009	0.002	790302
74	8485	0.456	0.007	0.002	1193017
75	8443	0.131	0.006	0.002	1314295
76	11193	0.085	0.010	0.003	1072476
77	9320	0.680	0.013	0.003	729991
78	9031	0.666	0.013	0.003	678085
79	9996	0.581	0.012	0.003	812619
80	8292	0.540	0.012	0.003	670117
81	7834	0.468	0.011	0.002	717067
82	6542	0.534	0.007	0.002	961377
83	6094	0.571	0.008	0.002	769812
84	9432	0.186	0.008	0.002	1188716
85	9151	0.268	0.007	0.002	1224150

AVERAGE C.V. FOR THE MEAN: .238

Table 8. Data used to generate age-length keys for 1976-1985. (Length; number measured, Ages; number aged).

AGE KEY NO.	GEAR	YEAR	UNIT AREA	SAMPLE SIZE	LANDINGS
1	OTB	(Jan-Dec76)	4TU,F,K,N,O,Q	2782 Len. 284 Ages	6962
2	SNU,Misc.	(Jan-Dec76)	4TU,F,K,O,Q	6466 Len. 1220 Ages	4231
3	OTB	(Jan-Dec77)	4TU,G,L	964 Len. 151 Ages	4634
4	SNU,Misc.	(Jan-Dec77)	4TG,K,L,M,N	5154 Len. 856 Ages	4596
5	OTB	(Jan-Dec78)	4TU,K,N	407 Len. 79 Ages	4540
6	SNU,Misc.	(Jan-Dec78)	4T,G,K,L,N	1796 Len. 244 Ages	4491
7	OTB	(Jan-Dec79)	4TU,G,N	1363 Len. 263 Ages	4523
8	SNU	(Jan-Dec79)	4TU,K,L,M	1400 Len. 220 Ages	3724
9	GN,Misc.	(Jan-Dec79)	4TU,N	200 Len 33 Ages	1749
10	OTB	(Jan-Dec80)	4TU,N,K	800 Len. 94 Ages	3887
11	SNU,Misc.	(Jan-Dec80)	4TU,F,G,L,N	1251 Len. 181 Ages	4405
12	OTB	(Jan-Dec81)	4TU,K	789 Len. 130 Ages	2623
13	SNU,Misc.	(Jan-Dec81)	4TU,F,G,K,L,N	2262 Len. 287 Ages	5211
14	OTB	(Jan-Dec82)	4TU,G,N	1416 Len. 217 Ages	1459
15	SNU,Misc.	(Jan-Dec82)	4TU,F,G,K,L,N	2417 Len. 345 Ages	5083
16	OTB	(Jan-Dec83)	4TU,F,G,H,L,M,N,O	493 Len. '83 A	1402
17	SNU,Misc.	(Jan-Dec83)	4TU,F,G,H,L,M,N,O	4698 Len. 707 Ages	5083
18	OTB	(Jan-Dec84)	4TU,F,G,L,M,N,O	1771 Len. 345 Ages	3176
19	SNU	(Jan-Dec84)	4TU,F,G,L,M,N,O	3888 Len. 235 Ages	3721
20	GN,Misc.	(Jan-Dec84)	4TU,F,G,L,M,N,O	695 Len. 259 Ages	2534
21	OTB	(Jan-Dec85)	4TU,F,G,L,M,N	1786 Len. 540 Ages	3765
22	SNU	(Jan-Dec85)	4TU,F,G,L,M,N	4896 Len. 764 Ages	3795
23	GN,Misc.	1985	4TU,F,G,L,M,N	722 Len. 202 Ages	1592

Table 9. Landing at age (x 103) for 4T American plaice.

	I	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
6	I	498	724	884	544	81	41	30	28	307	211
7	I	1483	2390	2978	1508	615	190	127	210	653	690
8	I	2643	2817	3372	5203	1129	461	511	320	736	1151
9	I	2784	2600	3289	6970	2771	717	1188	515	1068	1623
10	I	3438	2786	3137	5024	2640	1564	2140	541	1666	2263
11	I	3188	1934	3040	3166	2279	1190	1879	1146	2075	1963
12	I	4165	2780	2767	1899	2722	1417	1921	849	1674	1980
13	I	2308	1002	2045	1357	2372	944	1309	1031	1194	1291
14	I	1166	924	1273	1395	1663	1314	1045	701	1348	719
15	I	699	478	932	396	1586	2047	552	512	1172	617
16	I	873	504	507	266	713	949	512	507	503	576
17	I	457	238	266	158	462	1286	374	478	474	261
18	I	367	401	122	36	97	803	315	315	438	153
19	I	392	118	88	73	106	203	29	337	241	94
20	I	285	338	66	78	133	280	28	158	130	46
21	I	171	21	104	95	39	221	117	88	76	1
6+I		24917	20055	24870	28168	19408	13627	12077	7736	13755	13639

Table 10. Percent Landings at age for 4T American plaice.

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
6	1.9986	3.6101	3.6101	1.9313	0.4174	0.3008	0.2484	0.3619	2.2319	1.5474
7	5.9518	11.9172	11.9172	5.3536	3.1688	1.3952	1.0516	2.7146	4.7474	5.0601
8	10.6072	14.0464	14.0464	18.4713	5.8172	3.3835	4.2312	4.1365	5.3508	8.4336
9	11.1731	12.9643	12.9643	24.7444	14.2776	5.2632	0.8369	6.6572	7.7644	11.9023
10	13.7978	13.8918	13.8918	17.8358	13.6026	11.4787	17.7196	6.9933	12.1120	16.5811
11	12.7945	9.6435	9.6435	11.2397	11.7426	8.7302	15.5585	14.8139	15.0854	14.3957
12	16.7155	13.8619	13.8619	6.7417	14.0251	10.4010	15.9063	10.9747	12.1701	14.5204
13	9.2628	4.9963	4.9963	4.8175	12.2218	6.9256	10.8388	13.3273	8.6805	9.4676
14	4.6795	4.6073	4.6073	4.9524	8.5686	9.6408	8.6528	9.0615	9.8001	5.2728
15	2.8053	2.3834	2.3834	1.4059	8.1719	15.0209	4.5707	6.6184	8.5205	4.5248
16	3.5036	2.5131	2.5131	0.9443	3.6737	6.9674	4.2395	6.5538	3.6569	4.2241
17	1.8341	1.1867	1.1867	0.5609	2.3805	9.4403	3.0968	6.1789	3.4460	1.9141
18	1.4729	1.9995	1.9995	0.1278	0.4998	5.8897	2.6083	4.0719	3.1843	1.1220
19	1.5732	0.5884	0.5884	0.2592	0.5462	1.4871	0.2401	4.3563	1.7521	0.6894
20	1.1438	1.6854	1.6854	0.2769	0.6853	2.0551	0.2318	2.0424	0.9451	0.3373
21	0.6863	0.1047	0.1047	0.3373	0.2009	1.6207	0.9688	1.1375	0.8525	0.0073

Table 11. Ratio from the new landing at age matrix and landing at age from Metuzals 1985.

LANDING AT AGE FROM METUZALS, 1985 14/5/86

	I	1976	1977	1978	1979	1980	1981	1982	1983	1984
6	I	639	808	679	357	51	39	25	28	281
7	I	1679	2509	1793	990	454	138	33	208	631
8	I	2518	2632	2880	3739	938	452	314	316	715
9	I	2200	2238	2110	6871	1824	915	882	511	993
10	I	2466	2012	2107	3093	1716	1576	1393	548	1612
11	I	2037	1527	1724	1866	1646	948	1265	1147	2104
12	I	2584	1747	1156	1124	1927	893	1462	867	1589
13	I	1397	866	1100	1020	1271	642	957	1050	788
14	I	781	435	540	694	1105	637	837	718	1229
15	I	420	210	407	250	762	975	410	531	1085
16	I	431	117	113	155	416	533	386	526	533
17	I	374	73	77	104	267	697	272	495	453
18	I	233	101	83	31	90	405	236	327	441
19	I	274	53	44	63	67	127	19	349	208
20	I	187	62	27	77	32	146	21	164	119
21	I	111	11	179	109	29	140	144	91	73
6 +	I	18331	15401	15019	20543	12595	9263	8656	7876	12854

NEW LANDING AT AGE / LANDING AT AGE FROM METUZALS, 1985 14/5/86

	I	1976	1977	1978	1979	1980	1981	1982	1983	1984
6	I	0.779	0.896	1.166	1.524	1.588	0.923	1.200	1.000	1.093
7	I	0.883	0.953	1.489	1.523	1.355	1.210	3.848	1.010	1.035
8	I	1.050	1.070	1.049	1.392	1.204	0.896	1.627	1.013	1.029
9	I	1.265	1.162	1.397	1.014	1.519	0.689	1.347	1.008	1.076
10	I	1.394	1.385	1.334	1.624	1.538	0.872	1.536	0.987	1.033
11	I	1.565	1.267	1.580	1.697	1.385	1.102	1.485	0.999	0.986
12	I	1.612	1.591	2.145	1.690	1.413	1.394	1.314	0.979	1.053
13	I	1.652	1.157	1.666	1.330	1.866	1.291	1.368	0.982	1.515
14	I	1.493	2.124	2.113	2.010	1.505	1.812	1.249	0.976	1.097
15	I	1.664	2.276	2.052	1.584	2.081	1.844	1.346	0.964	1.080
16	I	2.026	4.308	4.018	1.716	1.714	1.565	1.326	0.964	0.944
17	I	1.222	3.260	3.091	1.519	1.730	1.621	1.375	0.966	1.046
18	I	1.575	3.970	1.313	1.161	1.078	1.741	1.335	0.963	0.993
19	I	1.431	2.226	1.795	1.159	1.582	1.402	1.526	0.966	1.159
20	I	1.524	5.452	2.185	1.013	4.156	1.685	1.333	0.963	1.092
21	I	1.541	1.909	0.520	0.872	1.345	1.386	0.813	0.967	1.041

Table 12. Average weight at age and biomass at age.

AVERAGE WEIGHT AT AGE

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
6 I	0.180	0.164	0.200	0.228	0.140	0.170	0.327	0.268	0.265	0.279
7 I	0.230	0.240	0.219	0.206	0.218	0.234	0.308	0.376	0.259	0.319
8 I	0.264	0.264	0.245	0.239	0.251	0.249	0.296	0.397	0.327	0.381
9 I	0.300	0.309	0.310	0.275	0.292	0.285	0.324	0.426	0.377	0.445
10 I	0.326	0.340	0.316	0.334	0.295	0.340	0.366	0.463	0.429	0.457
11 I	0.367	0.401	0.366	0.389	0.383	0.400	0.417	0.511	0.539	0.543
12 I	0.457	0.539	0.347	0.428	0.467	0.406	0.481	0.508	0.643	0.668
13 I	0.480	0.516	0.480	0.520	0.450	0.564	0.617	0.710	0.743	0.869
14 I	0.581	0.797	0.462	0.581	0.582	0.635	0.721	0.858	0.941	0.975
15 I	0.685	0.770	0.654	0.830	0.558	0.664	0.786	0.950	0.971	1.182
16 I	0.801	1.080	0.660	0.926	0.652	0.815	0.850	1.030	1.124	1.275
17 I	0.898	1.296	0.566	1.189	0.778	0.841	0.993	1.160	1.214	1.288
18 I	1.066	1.427	1.046	1.344	1.10	0.888	1.034	1.330	1.379	1.561
19 I	1.044	1.370	1.461	1.395	0.970	1.026	1.393	1.390	1.510	1.647
20 I	1.167	1.427	0.939	1.200	0.560	1.241	1.430	1.380	1.605	2.164
21 I	1.300	1.925	1.129	1.270	1.650	1.283	1.240	1.690	1.698	2.174

LANDED BIOMASS: LANDING AT AGE X AVERAGE WEIGHT AT AGE 14/5/86

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
6 I	89	119	177	124	11	7	10	8	81	59
7 I	342	574	653	311	134	44	39	79	169	220
8 I	697	744	826	1242	283	115	151	127	240	439
9 I	836	802	1020	1915	809	204	385	219	403	723
10 I	1120	948	992	1676	779	532	784	251	715	1034
11 I	1169	775	1112	1233	873	476	784	586	1119	1066
12 I	1904	1497	959	812	1271	575	925	431	1076	1322
13 I	1108	517	982	706	1068	532	807	732	887	1122
14 I	678	736	588	811	968	834	753	601	1268	701
15 I	479	368	609	329	885	1358	434	486	1138	729
16 I	699	544	335	246	465	773	435	522	566	735
17 I	410	309	151	188	360	1081	372	554	575	336
18 I	391	572	128	48	98	713	326	419	604	239
19 I	409	162	129	102	103	208	40	468	364	155
20 I	333	482	62	94	74	348	40	218	209	100
21 I	222	40	117	121	64	284	145	149	129	2
6 + I	10886	9191	8838	9957	8244	8084	6430	5851	9544	8982

Table 13. Research vessel population number at age.

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0														234	1057	121
1	1712	1400	1168	993	922	545		798		91	2974	3103	1897	3253	232	2744
2	7583	9461	9176	8034	18636	5156	5884	6330	1370	1540	8019	16483	15544	13245	2981	16234
3	11847	29328	16496	26276	64798	25644	59064	90135	10840	7665	39574	33644	16299	32618	5507	25547
4	23252	48966	37843	36639	130876	95818	197121	257387	88004	74345	90164	81909	20459	39158	25687	36722
5	36113	47123	36774	42518	110123	178900	289252	351432	116372	204063	101957	110050	39081	48014	34635	43951
6	40425	49001	41201	33039	90010	91299	228064	205926	129669	184374	127198	130221	33794	46659	32686	37678
7	35818	50664	47279	27779	59184	70624	109035	137253	119445	207198	89620	141124	50576	34716	29538	33274
8	20593	30873	32534	30751	45718	44750	47745	60472	79187	155869	72035	81895	69446	55741	27711	32255
9	6777	10686	14796	24065	51049	31999	42812	24545	26009	71746	37257	55238	36334	52904	25492	16492
10	4265	7477	8706	10710	31185	21557	29827	16484	16810	36973	19601	28891	24191	30605	30225	10129
11	4215	6626	4124	5678	13942	16541	20120	9753	8860	20607	11868	13128	10192	30417	11219	5625
12	3296	4261	3968	4354	4542	4844	13297	6670	4511	11130	6570	6356	4473	15541	9618	3391
13	2119	3132	2063	3561	3788	2699	7914	4138	4929	6802	4614	3659	2310	6473	4536	1646
14	1650	2656	1320	4032	3844	2085	4112	2399	1612	6267	2415	2297	2481	3167	1717	1255
15	1001	1631	578	2183	2743	1245	1782	1338	1493	3312	1014	1656	1391	2529	1724	645
16	761	1373	724	1663	1399	1207	1547	364	577	2411	512	1457	1402	1365	693	729
17	707	1201	179	1512	679	166	1616	500	341	592	406	468	1082	1355	585	411
18	506	528	185	663	602	1223	616	146	143	771	126	191	437	999	564	240
19	44	137	62	1854	194	647	49	671	149	425	160	402	576	365	436	270
20+	168	406	64	1895	398	1033	741	133	295	1140	197	422	491	643	654	274
0+	202852	306930	259240	268199	634632	597982	1060598	1176874	610616	997321	616281	712594	332456	420001	247497	269633

Table 14. Research vessel average weight at age.

		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
6	I	0.175	0.149	0.128	0.110	0.129	0.135	0.138	0.140	0.140	0.214
7	I	0.242	0.222	0.184	0.152	0.186	0.170	0.174	0.150	0.177	0.271
8	I	0.323	0.331	0.265	0.216	0.248	0.234	0.212	0.176	0.229	0.302
9	I	0.400	0.403	0.385	0.301	0.328	0.289	0.276	0.220	0.276	0.393
10	I	0.445	0.493	0.456	0.369	0.413	0.362	0.361	0.254	0.303	0.500
11	I	0.616	0.604	0.613	0.490	0.555	0.447	0.486	0.334	0.391	0.695
12	I	0.692	0.745	0.649	0.534	0.702	0.660	0.691	0.434	0.466	0.703
13	I	0.923	0.887	0.813	0.726	0.903	0.742	0.804	0.609	0.571	1.012
14	I	1.089	1.039	1.143	0.892	1.195	0.956	1.039	0.828	0.790	1.132
15	I	1.177	1.402	1.232	1.265	1.451	1.200	1.116	0.877	0.966	1.173
16	I	1.792	1.563	1.754	1.382	1.730	1.283	1.469	1.145	1.245	1.540
17	I	1.617	1.542	1.740	1.746	1.579	1.300	1.400	1.234	1.256	2.053
18	I	2.383	1.925	1.887	1.920	2.458	1.817	1.433	1.379	1.598	2.113
19	I	2.700	1.767	2.186	2.282	2.069	2.070	2.080	1.429	1.775	1.979
20	I	2.500	2.350	2.383	2.111	2.550	1.125	2.150	2.350	2.259	2.813
21	I	1.508	2.800	2.264	2.308	1.800	2.264	2.800	1.592	2.104	2.650

Table 15. Mortality (Z) estimates from Research Vessel Survey Data.

AGE	81-82	82-83	83-84	84-85	MEAN
1	-1.611	-1.943	.087	-4.248	-1.929
2	.011	-.741	.878	-2.148	-.500
3	.497	-.877	.239	-1.897	-.509
4	.740	-.853	.123	-.537	-.132
5	1.181	-.177	.385	-.084	.326
6	.946	-.027	.457	-.018	.340
7	.709	-.097	.225	-.088	.187
8	.813	.272	.782	.519	.597
9	.826	.172	.560	.923	.620
10	1.042	-.229	1.004	1.681	.874
11	1.077	-.422	1.151	1.196	.751
12	1.012	-.370	1.231	1.765	.910
13	.389	-.316	1.327	1.285	.671
14	.502	-.019	.608	.979	.517
15	.167	.019	1.295	.861	.585
16	.298	.034	.847	.522	.425
17	.069	.080	.877	.891	.479
18	-1.104	.180	.829	.737	.160

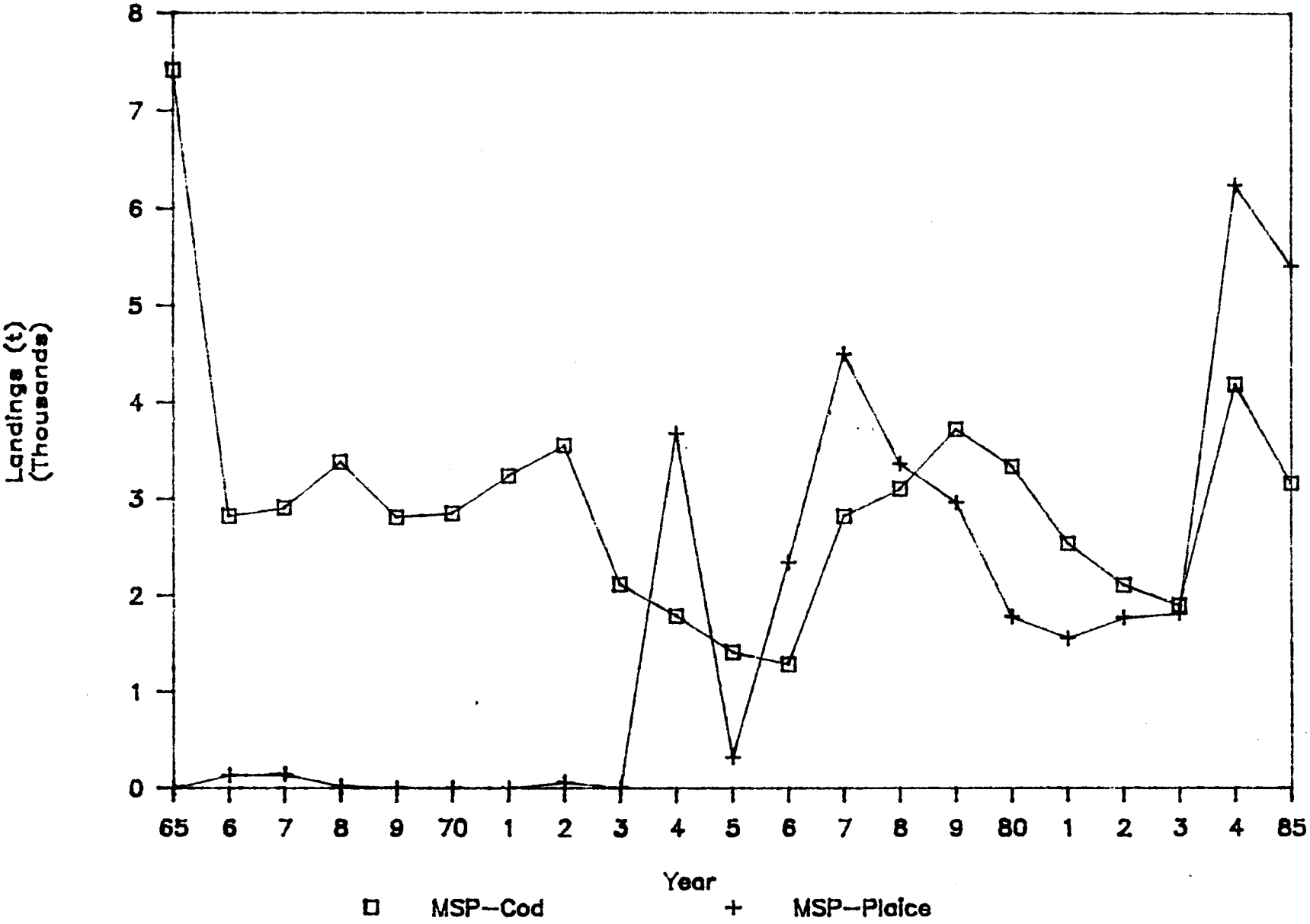
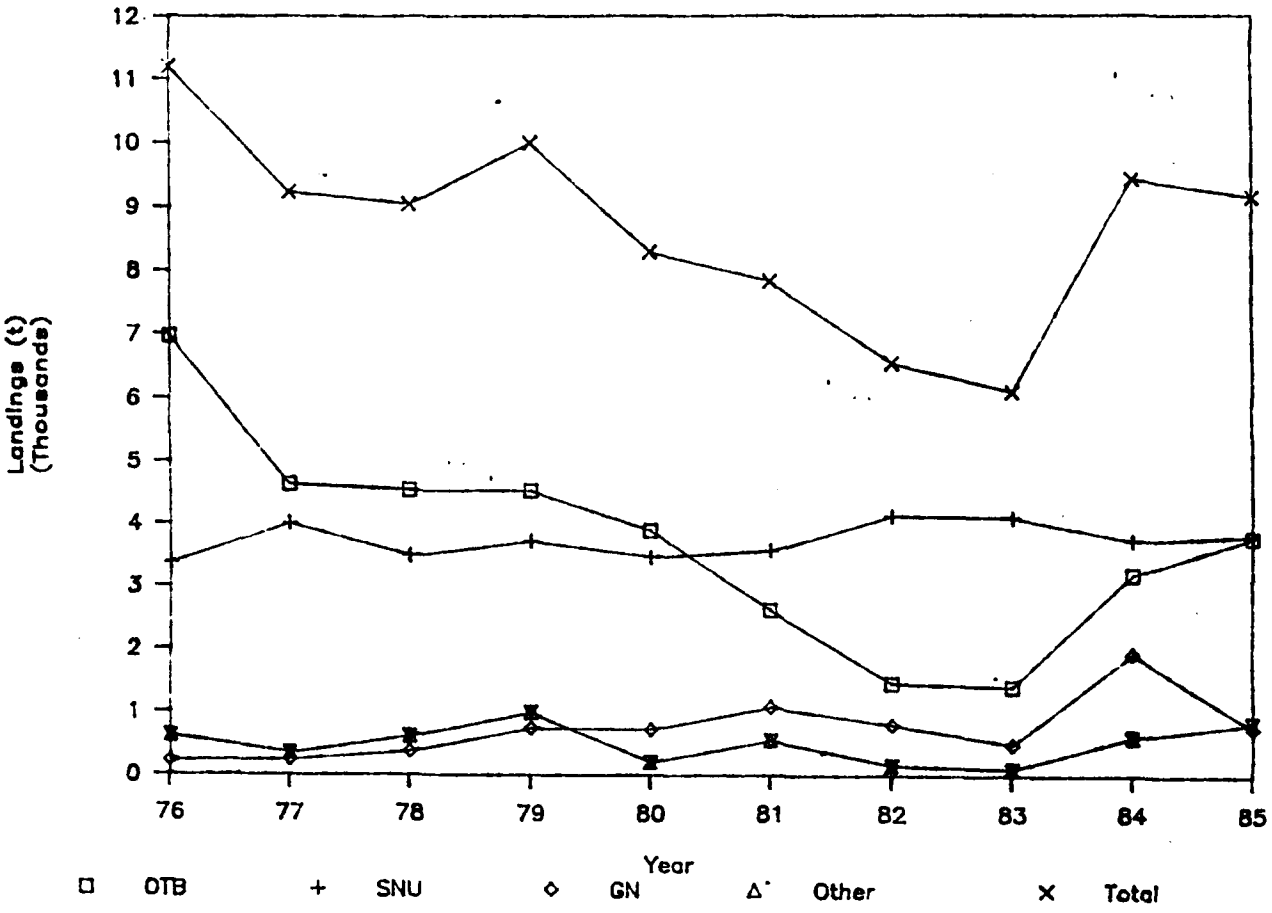


Figure 1: Historical landing of 4T American Plaice from the Plaice directed fishery and the cod directed fishery.



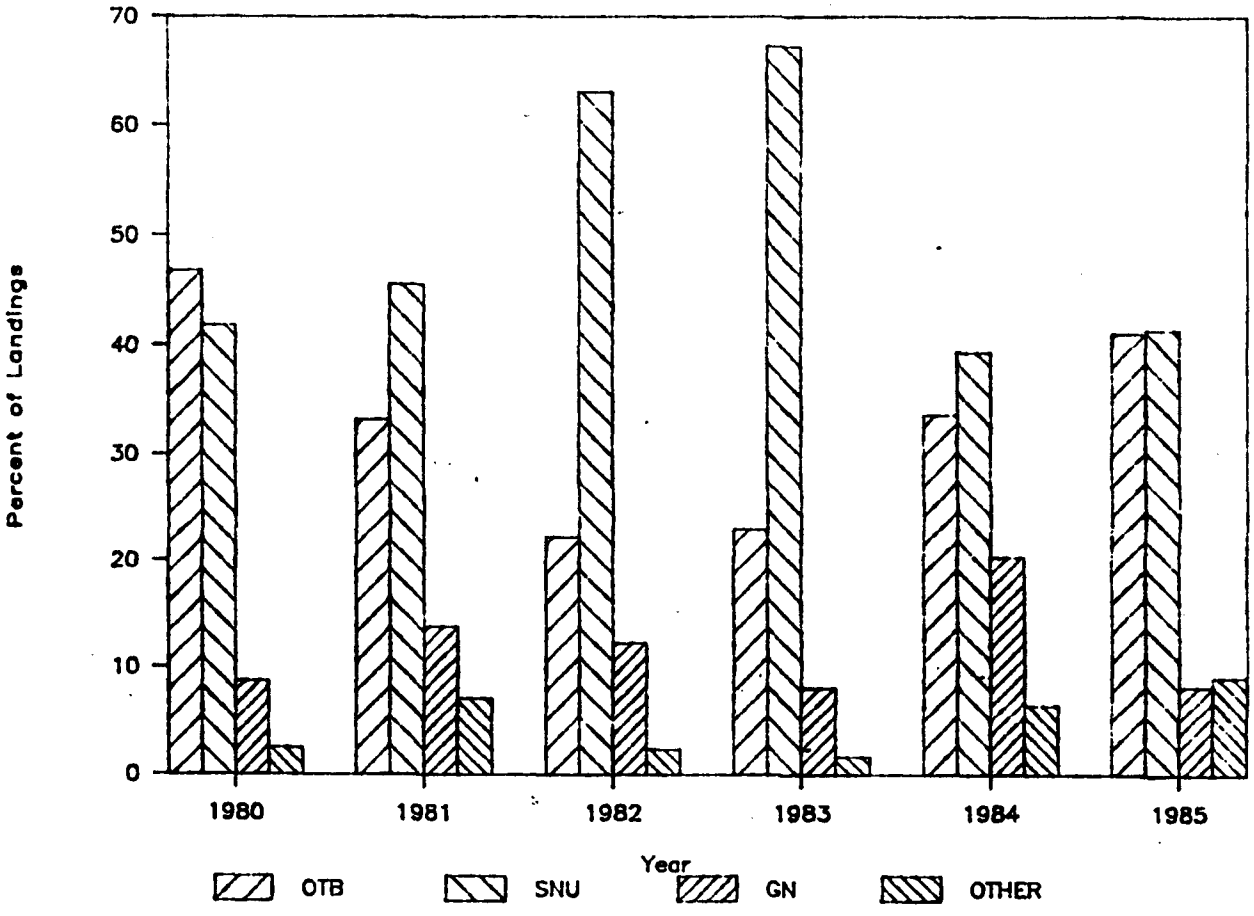
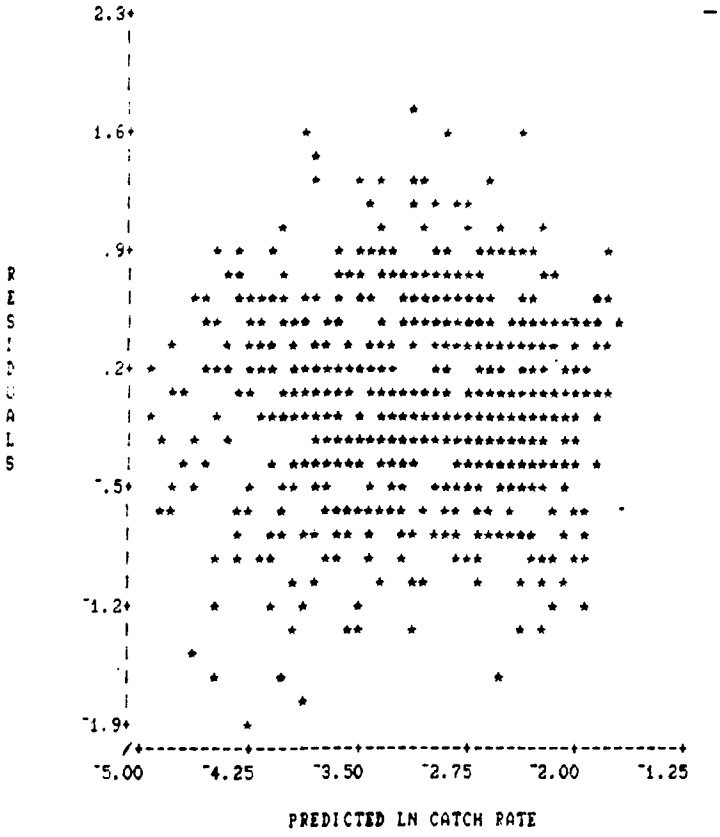
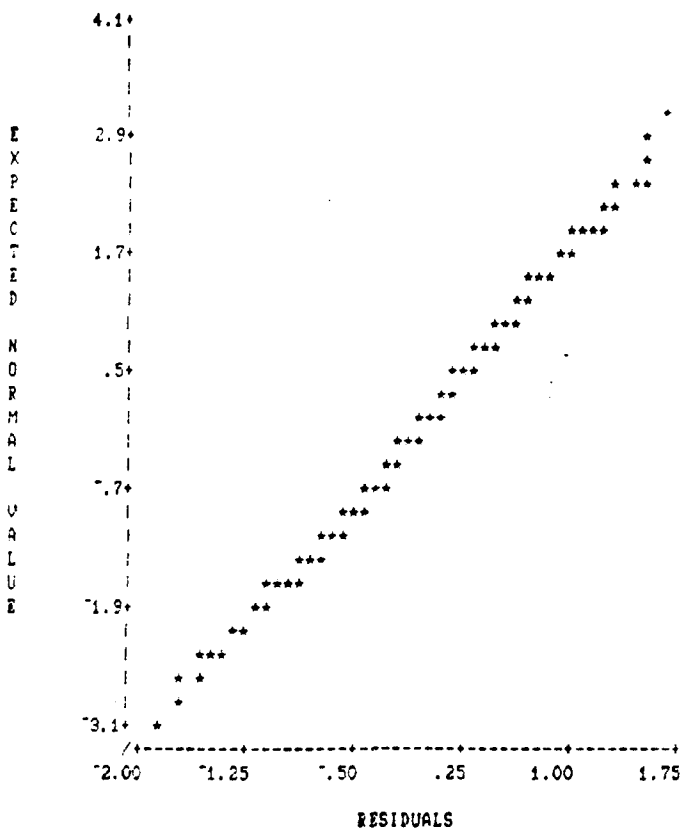


Figure 2: Historical landing by gear of 4T American Plaice.





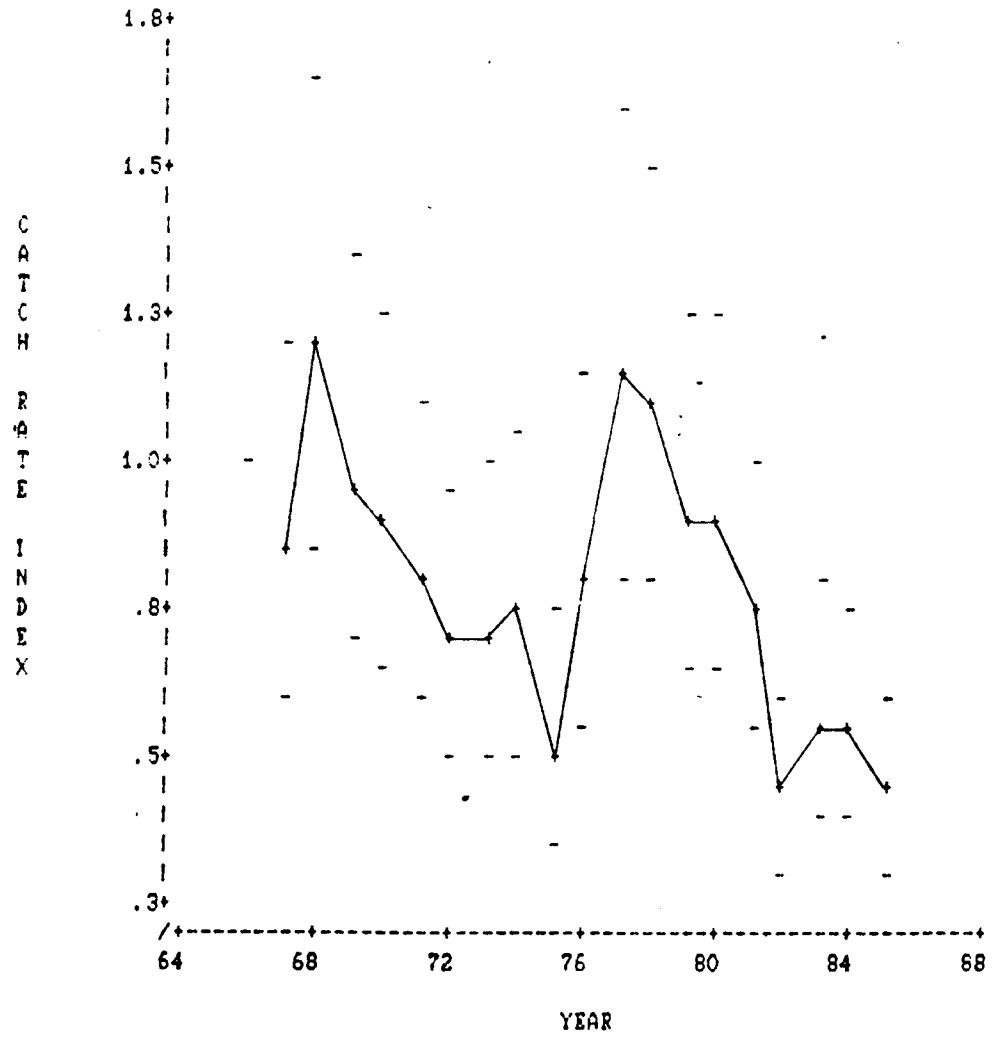
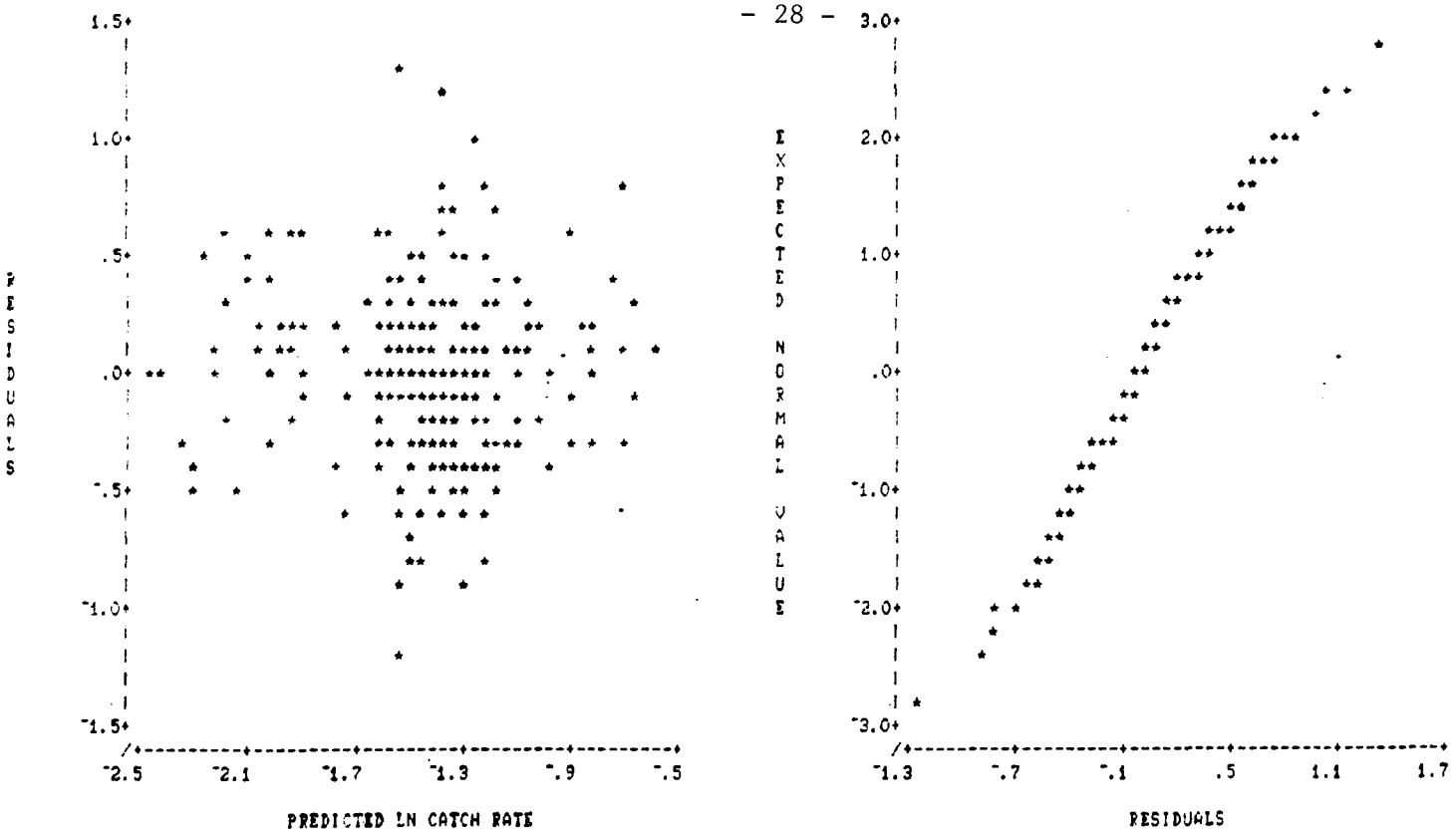


Figure 3: Catch rate index from the multiplicative model; by-catch fishery.



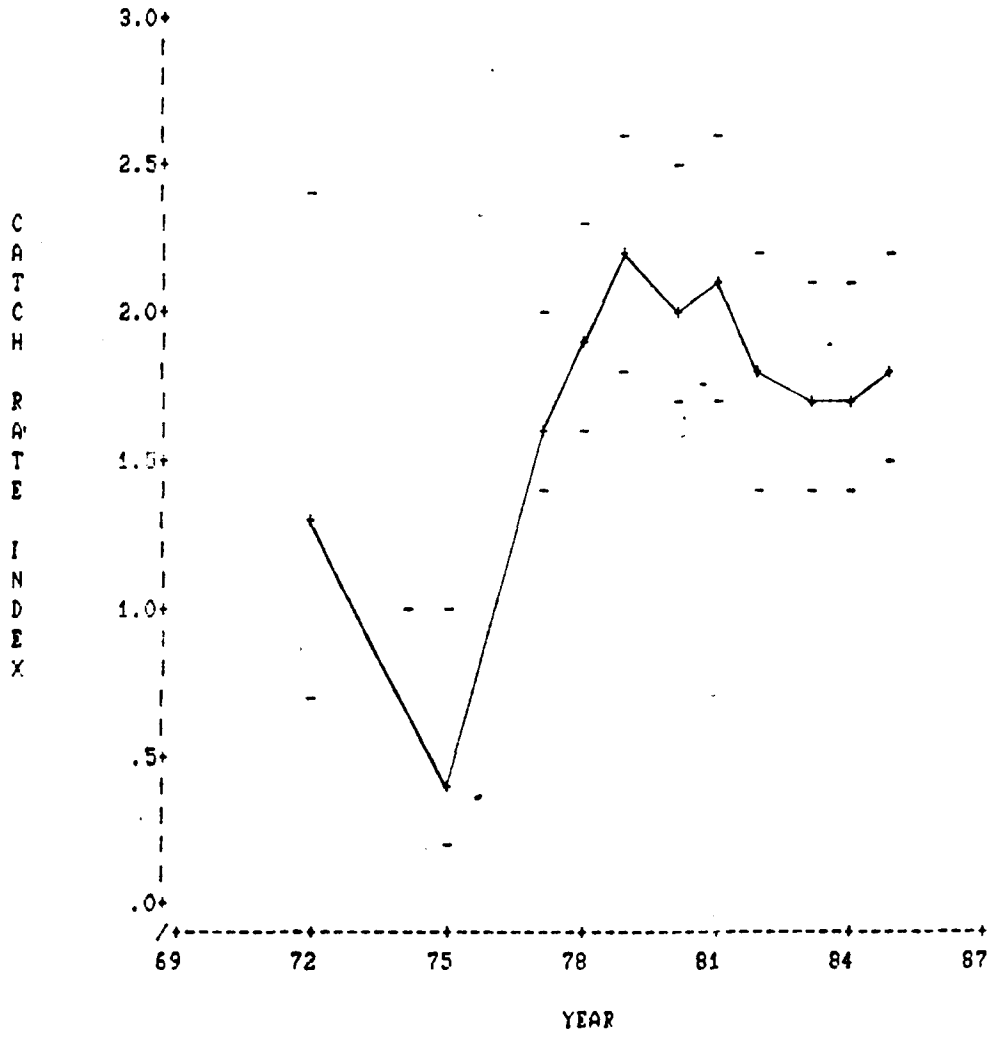
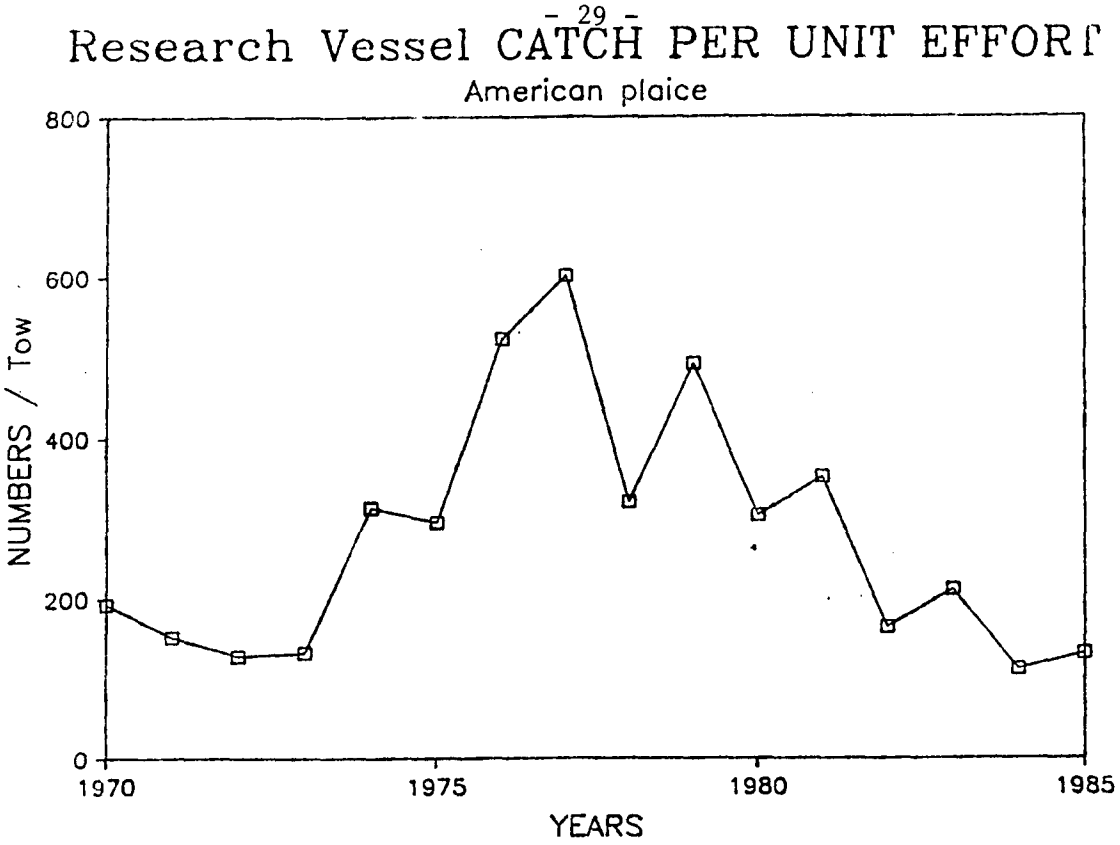


Figure 4: Catch rate index from the multiplicative model; Plaice directed fishery.

A:



B:

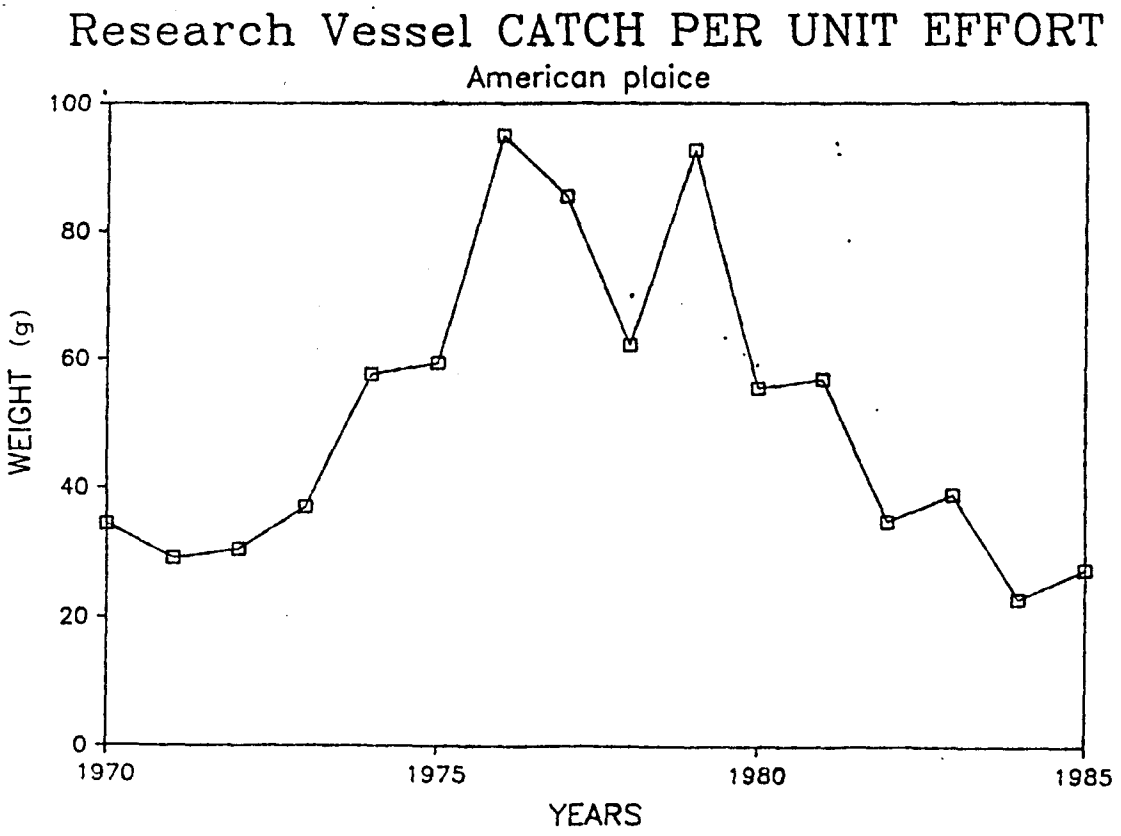


Figure 5: Catch rates from the RV survey
A) Numbers per standard tow
B) Weight per standard tow

YIELD PER RECRUIT ANALYSIS

SUMMARY:

AGE	WEIGHT-AT-AGE	PARTIAL RECRUITMENT
6	0.279	0.010
7	0.319	0.028
8	0.381	0.041
9	0.445	0.091
10	0.457	0.181
11	0.543	0.349
12	0.668	0.493
13	0.869	0.675
14	0.975	1.000
15	1.182	1.000
16	1.275	1.000
17	1.288	1.000
18	1.561	1.000
19	1.647	1.000
20	2.164	1.000
21	2.174	1.000

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	0.1000	0.104	0.098	0.943	1.816
	0.2000	0.166	0.142	0.856	1.313
	0.3000	0.207	0.163	0.788	1.005
F0.1—	0.3020	0.208	0.163	0.787	1.000
	0.4000	0.237	0.174	0.736	0.804
	0.5000	0.260	0.180	0.695	0.667
	0.6000	0.279	0.184	0.662	0.568
	0.7000	0.295	0.187	0.635	0.494
	0.8000	0.309	0.189	0.612	0.437
	0.9000	0.321	0.190	0.593	0.391
	1.0000	0.332	0.192	0.577	0.354
	1.1000	0.342	0.193	0.563	0.324
	1.2000	0.352	0.194	0.550	0.298
	1.3000	0.361	0.194	0.539	0.276
	1.4000	0.369	0.195	0.529	0.258
	1.5000	0.376	0.196	0.520	0.241
FMAX—	1.5000	0.376	0.196	0.520	0.241

NATURAL MORTALITY RATE : 0.2
F0.1 COMPUTED AS 0.3020 AT Y/R OF 0.1634
FMAX COMPUTED AS 1.5000 AT Y/R OF 0.1958

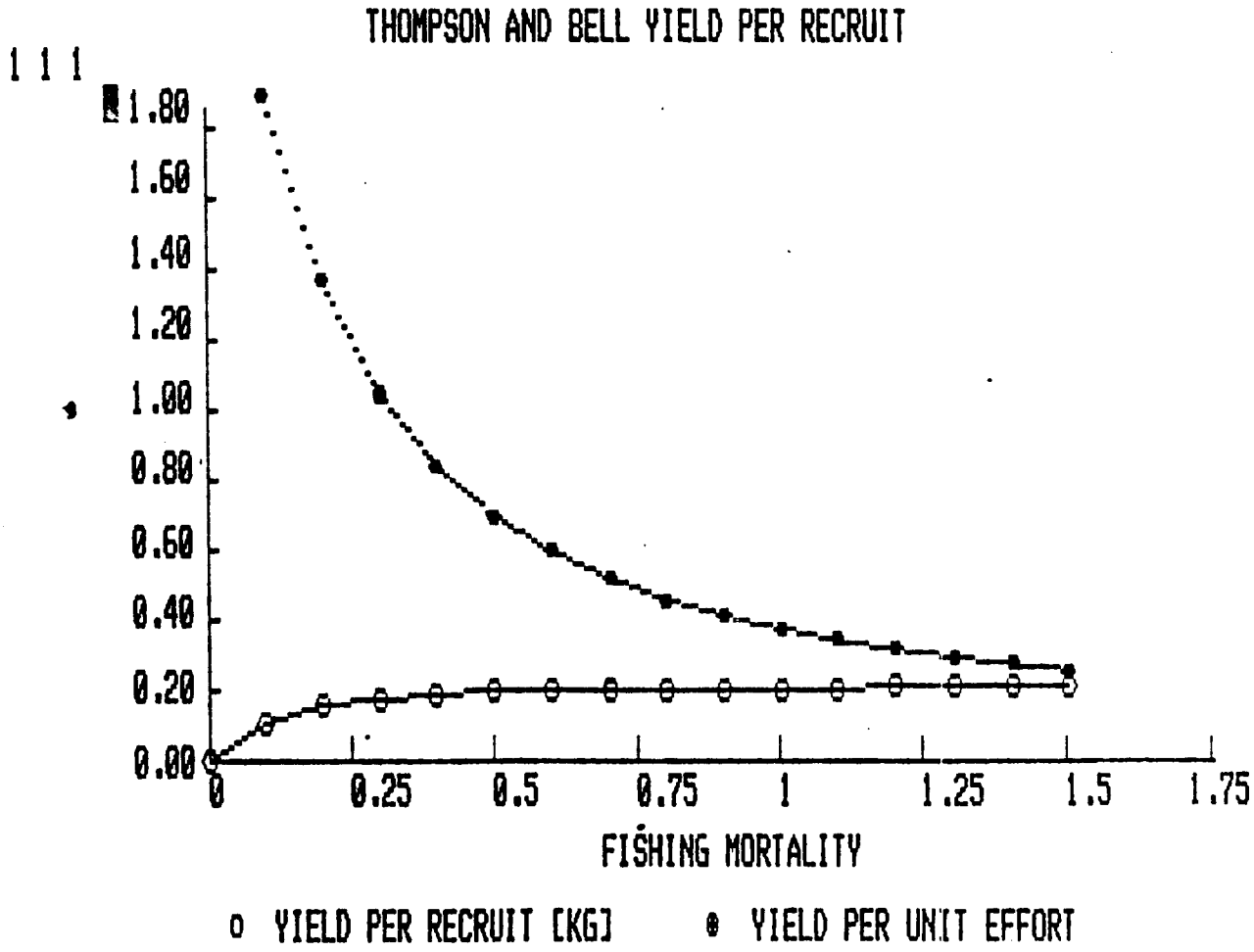


Figure 6: Results from the Thompson and Bell Yield Per Recruit Analysis.

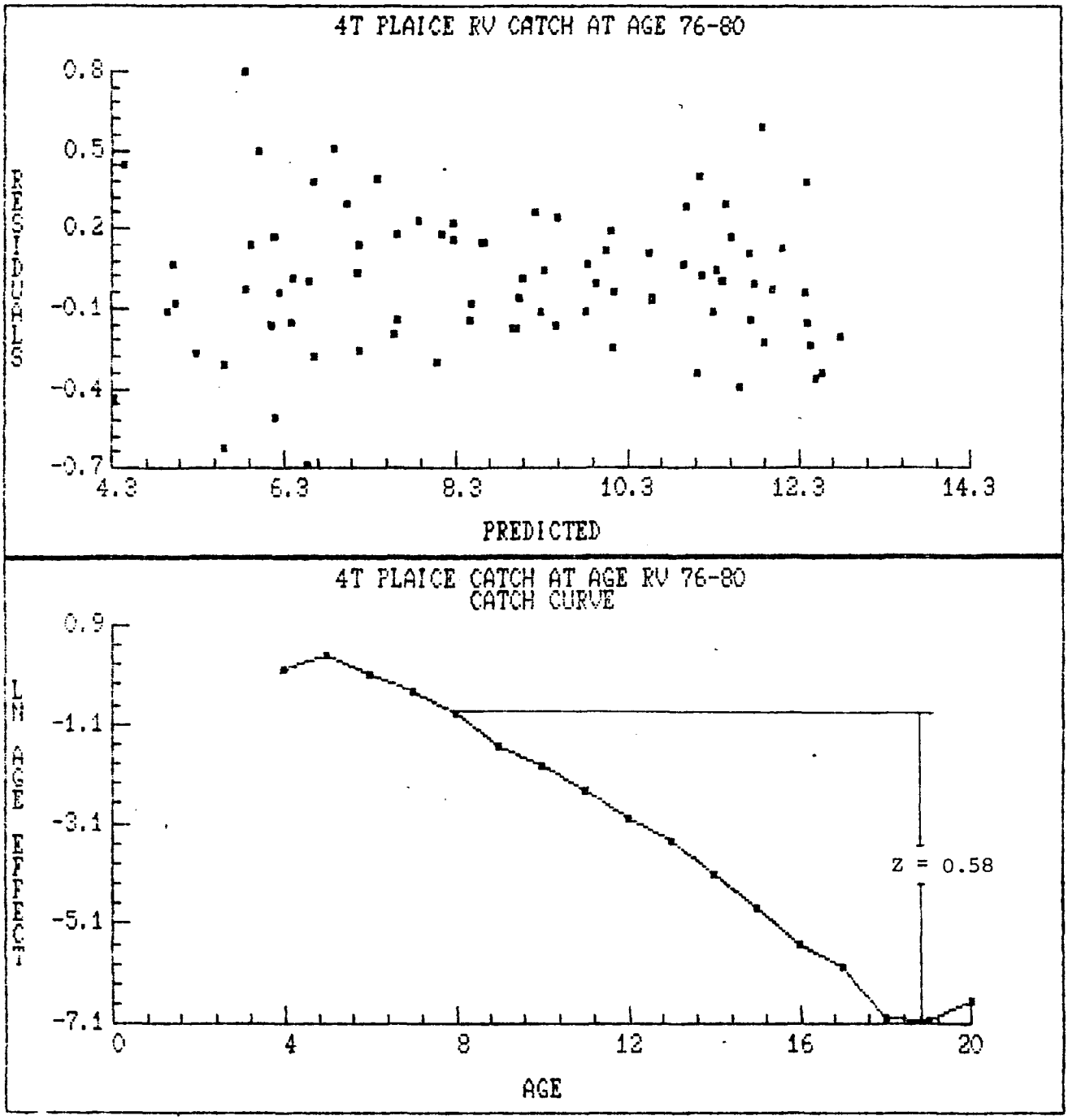


Figure 7: Results from the Multiplicative Analysis of the research vessel catch at age; 1976-1980.

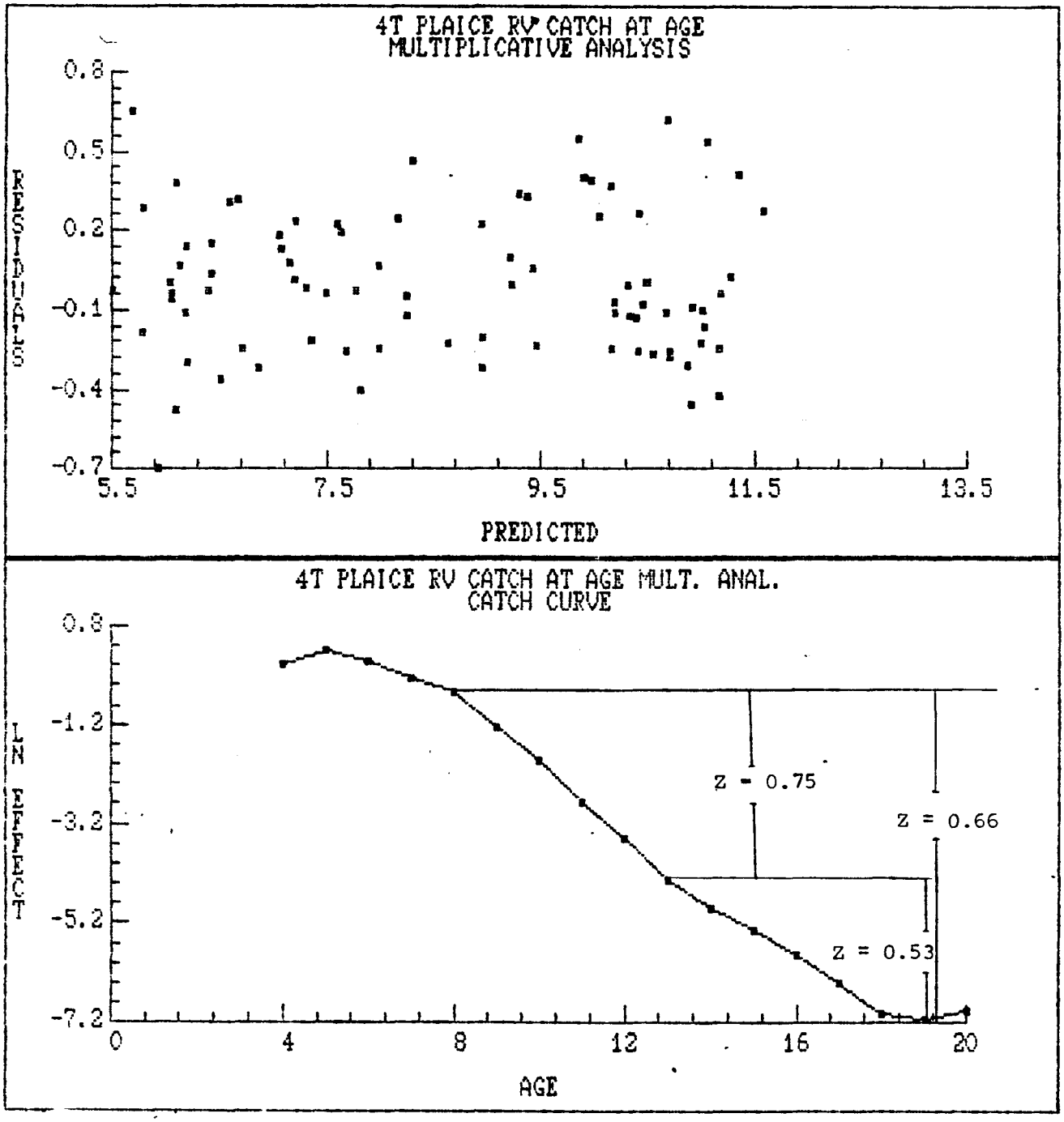


Figure 8: Results from the Multiplicative Analysis of the research vessel catch at age; 1981-1985.