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Stock Assessment of American Plaice (Hippoglossoides platessoides F.) in ICNAF Division 4T

by

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INTRODUCTION

Catch Statistics

The American plaice fishery in the Gulf of St. Lawrence has maintained an almost constant level of landings since the early 1960's (Table 1). Historically, landings were minimal, but with the introduction of the otter-trawl in 1947 and the Danish seine in 1958 (Powles 1969) landings increased markedly and have fluctuated around 9,000 t annually (Figure 1).

The fishing season ranges from April through until December with peak landings during the summer months (Table 2). Of the small vessels in the Gulf fishing groundfish, Otter trawls and Danish (or Scottish) seiners are most important in catching plaice (Table 3).

The fishery concentrates on two groups in the Magdalen Shallows, one near the Miscou Islands and the other near Cape Breton (Powles 1964,1965). For management purposes, the groups are combined and will be assessed as a unit stock in this paper.

Unspecified flounder catch for 1978 is not included in the total provisional catch for plaice.

Catch Composition

Two age-length keys were obtained from the twelve commercial samples. No noticeable difference was observed in the numbers-at-age taken in 1978 by the two major gears, OTB1 (Side Otter Trawl) and SDN (Danish Seine) and thus the females were combined for one age-length key and the males for another. It is evident from the commercial samples that 90% of the landings are composed of female plaice, an increase of 10% over last year. A high percentage of females is quite common in plaice landings (Pitt, pers. comm.). This percentage was then used to apportion the total landings by sex, and numbers-at-age of males and females landed were obtained.

Discards estimates in the Gulf were first made by Powles (1960) and Jean (1963) who calculated discards of plaice as high as 60% by weight. In a study by McLaren Atlantic Limited in 1976, total discards were estimated to be as high as 40% by weight. The discard estimates per age obtained by McLaren were used in 1977 by Schweigert (1978), Gray, 1978 (pers. comm.) and will again be used in this paper.

Approximate % Discards in Number for 1976

Age	3	4	5	6	7	8	9	10	11	12	13	14
Males	100	100	97	91	81	67	31	17	9	4	1	0
Females	100	100	95	86	69	27	9	2	0	0	0	0

The total number of fish caught (including discards) at each age in 1978 was estimated the following way.

If 95% of the number of female plaice were discarded at age 5, then the landings only represent 5% of the actual catch. Therefore, in order to obtain the total estimated catch in numbers of age 5,
catch = landings x 100% ÷ 5%.

Discards were estimated for age 6-10 for females, and for 6-13 for males. The adjusted numbers-at-age were combined to give a total numbers-at-age for 1978. Numbers for 1964-1977 were taken from Schweigert (1978) and Gray (1978).

Effort

There are numerous small boats fishing for plaice in the Gulf. Most of the time, the effort is not at all directed for plaice, but cod. Otter trawlers usually direct their effort on cod; a large by-catch of plaice is unavoidable.

Smaller Danish and Scottish seiners usually fish for flounders, but do not direct their effort on any one species. It is therefore difficult to calculate effort specifically directed for plaice. Another difficulty in estimating directed effort on plaice, is the fact that around 1973, the great increase in the snow crab traps has forced the Danish seiners from fishing in the usual areas. The Danish seiners from Cheticamp, for instance, must now fish near the Magdalen Islands in the early summer in order to avoid the many crab traps, but by the end of November they are back on the 'traditional' grounds.

Effort indices were examined in detail for 1972-1978 for various gears (Table 4). Previous effort data is only available for combined flatfish landings in the ICNAF Statistical Bulletins.

The effort in hours fished was calculated separately for the most important gears, OTB1-2 (Tonnage class 25-49.9) and 3 (Tonnage class 50-149.9), as well as SDN-2 and 3 (Figure 2). These gears collectively

represent at most 65% and at least 40% of the total plaice catch (Figure 3) for the years 1972-1978.

Since plaice is mostly a by-catch in the cod fishery, the Chikuni estimates of effort (Chikuni 1976) were also generated for each gear (Figure 4). Total plaice catch was also divided by the (CPUE) in hours fished for cod, to obtain an estimate of total effective effort, since cod is the preferred species for otter trawls, and effort is almost solely directed towards cod. An index combining OTB1-2 and 3 was well as SDN 2 and 3 (CPUE) was also calculated to represent the greatest percentage of plaice caught (Table 5).

Most of the commercial CPUE indices indicate a constant CPUE, with a slight increase in 1977 and 1978.

METHODS

Cohort Analysis

A number of different estimates for the natural mortality of plaice are presently available. Beverton and Holt (1957) arrived at a combined (male and female) estimate of 0.1 for North Sea Plaice (Pleuronectes platessa). This was obtained from the loss rates, of the European trans-wartime year-classes. Beverton (1964) in a later analysis suggested that the estimates should be .08 for male and 0.12 for female. For ages 5-15 it can be shown that the instantaneous mortality rate calculated by the curve is .097 per year (Cushing 1975). Powles (1969) estimated 0.13 for male and 0.17 for female plaice in the Gulf of St. Lawrence. Pitt (1973) calculated natural mortality using the method employed by Halliday (1971) and arrived at higher mortalities for plaice on the Grand Bank. Until further analyses are made on the Gulf plaice, the natural mortality data obtained by Powles (1969) have been averaged and 0.15 is used in this paper. No reasonable estimates of total mortality were obtained when Paloheimo's linear formula was used (Paloheimo 1961).

Cohort analysis (Pope 1972) was utilized to determine the numbers-at-age (Table 7); these were obtained by combining the catch-at-age (Table 8) for male and female plaice combined, and using the value of 0.15 for natural mortality. The resultant fishing mortalities are on Table 9 showing very low values.

In order to estimate fishing mortalities, a number of regressions of effort (DSN-2 and 3, OTB 1-2 and 3, and combined CPUE index) versus the predicted weighted F's of the cohort were made. Only the effort index, combining effort of DSN-2 and 3, and OTB 1-2 and 3 showed a linear relationship and thus the terminal F's were adjusted to give a better predictive fit (Figure 5).

The relationship between the 6+ biomass of the VPA and CPUE index of the combined efforts resulted in an R^2 of 91.58 (Figure 6).

The regression of recruits (6 and 7 year olds) of the VPA versus the 6 and 7 year olds of the research CPUE (Table 6) gave a good correlation of $R^2 = 81.99$ (Figure 7).

Yield Per Recruit and Projections

The final F values generated by the VPA are very low. The partial recruitment pattern from the resultant analysis is the following:

Partial Recruitment at Age for Males and Females Combined

Partial recruitment	.15	.4	.43	.5	1
Age	6	7	8	9	10

Using this partial recruitment and the following weights-at-age, yield per recruit was calculated (Table 10). The $F_{0.1}$ was 0.175. The 1978 fishing mortality was lower than the $F_{0.1}$. At an $F_{0.1}$ of 0.175 the yield was 0.173 kg per recruit.

The weights-at-age were obtained from different sources. Weights for ages 1-5 were estimated from values of the research cruise (1978) on the Scotian Shelf and weights for ages 6-16+ were obtained from commercial samples in the Gulf.

Females

Age	1	2	3	4	5	6	7	8	9	10
Wt(kg)	-	.03	.06	.10	.21	.25	.27	.31	.40	.47
Age	11	12	13	14	15	16	17	18	19	20
Wt(kg)	.52	.61	.67	.88	.95	.95	.88	1.25	1.97	1.45
Age	21	22	23	24	25	26	27+			
Wt(kg)	1.67	-	1.89	1.72	-	2.94	-			

Males

Age	1	2	3	4	5	6	7	8	9	10
Wt(kg)	-	0.03	0.6	.11	.13	.21	.24	.23	.31	.27
Age	11	12	13	14	15+					
Wt(kg)	.33	.35	.40	.46	.66					

The partial recruitment and weights-at-age of 1978 were used to project to 1980 with a catch of 10,000 tonnes and recruitment of the geometric mean of the recruits at ages 6 from 1964 to 1978 inclusive from the VPA.

Year	Pop. Numbers	Projection Biomass	Numbers	Biomass	Fully Recruited F
1978	304565	93943	29606	9646.02	0.1960
1979	293333	95565	26226	10000.08	0.1962
1980	286788	95675	25675	10000.08	0.1857

SUMMARY

From the analysis presented it appears that the fishing mortalities are very low and the stock seems to be slightly increasing. The cohort analysis is based on a catch matrix derived from very limited sampling and only one year's estimate of discards. Detailed CPUE indices are only available from 1972-1978 which is a very short range to look at the stock from a historical point of view. Fishing effort may have been greater than $F_{0.1}$ for past years since effort is mainly directed for cod; and no discards are recorded.

The yield per recruit and projected biomass from this analysis indicate, that at the present level of fishing, the stock can continue to support at least 10,000 t per year.

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Table 1. Updated statistics for 4T Plaice stocks.

Year	Landings (t)	Estimated Discards (t)	Total Catch (t)	Proportion of Discards to Catch
1964	6916 [1]	923	7836	.134
1965	8778	1623	10385	.185
1966	9362	2405	11780	.257
1967	7534	1813	9351	.241
1968	6921	2622	9568	.379
1969	6584	1614	8192	.245
1970	7582	1598	9201	.211
1971	7627	1876	9513	.246
1972	8294	884	9178	.107
1973	6905	899	7804	.130
1974	8485	454	8939	.054
1975	8443	1813	10256	.215
1976	11193	472	11665	.042
1977	9230 [2]	1598	10828	.173
1978	7414 [3]	1444 [4]	8858	(.195)
		Ave: 1471 Wt. Mean: 1444		Ave. .187

1) 1964-76
Schweigert, J. CAFSAC Res. Doc. 1978 incorporating data from MacLaren Atlantic Discard Study (MS 1976).
2) ICNAF Statistical Bulletin 1977.
3) Provisional Catch ICNAF
4) Estimated number using weighted mean of discards 1964-1978.

Table 2. 4T Plaice Seasonal Landings in Metric tonnes.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	NK	TOTAL
1972														
Can-MQ	18	8	-	207	1630	1783	1379	780	625	451	739	251	-	7871
Can-N	36	1	-	192	166	1	-	-	-	-	2	21	-	419
FRA-SP	-	-	-	4	-	-	-	-	-	-	-	-	-	4
TOTAL	54	9	-	403	1796	1784	1379	780	625	451	741	272	-	8294
1973														
CAN-MQ	4	-	-	59	714	1543	857	821	639	668	837	457	-	6599
CAN-N	-	-	-	253	9	-	-	-	-	-	4	22	-	288
FRA-SP	-	-	-	18	-	-	-	-	-	-	-	-	-	18
TOTAL	4	-	-	330	723	1543	857	821	639	668	841	479	-	6905
1974														
CAN-MQ	8	4	1	110	850	1462	1387	1153	987	740	1209	223	-	8134
CAN-N	4	-	-	114	99	7	-	-	-	-	-	103	-	327
FRA-M	-	-	-	9	1	-	-	-	-	-	-	-	-	10
FRA-SP	-	-	-	2	12	-	-	-	-	-	-	-	-	14
TOTAL	12	4	1	235	962	1469	1387	1153	987	740	1209	326	-	8485
1975														
CAN-MQ	6	2	-	41	1073	1314	1108	1155	1221	1043	843	254	-	8660
CAN-N	-	-	-	181	43	-	-	-	-	-	1	33	-	258
FRA-SP	1	-	-	87	-	-	-	-	-	-	3	21	-	112
PORT	11	2	-	-	-	-	-	-	-	-	-	-	-	13
TOTAL	18	4	-	309	1116	1314	1108	1155	1221	1043	847	308	-	8443
1976														
CAN-MQ	8	6	16	525	2531	1474	1084	1003	1065	605	309	69	-	8695
CAN-N	5	3	-	1497	890	-	-	-	-	2	15	-	-	2412
FRA-SP	-	-	-	36	-	-	-	-	-	-	38	12	-	86
TOTAL	13	9	16	2058	3421	1474	1084	1003	1065	607	362	81	-	11193
1977														
CAN-MQ	3	1	2	229	837	1464	1564	1592	1215	913	1323	10	-	9153
CAN-N	-	-	-	67	3	-	-	-	-	-	7	-	-	77
TOTAL	3	1	2	296	840	1464	1564	1592	1215	913	3330	10	-	9230
1978														
CAN-MQ	3	4	2	146	843	959	1018	905	955	1689	511	232	-	7267*
CAN-N	-	-	-	135	-	-	-	-	2	10	-	-	-	147
TOTAL	3	4	2	281	843	959	1018	905	957	1699	511	232	-	7414

* Provisional Catch, ICNAF

Table 3. Landings by Gear 4T Plaice in metric tonnes.

	GEAR	OTB1				OTB2					SDN			SSC		GILL-NETS[1]			OTHERS[2]					
YEAR	TONNAGE CLASS	1	2	3	4	1	2	3	4	5	1	2	3	2	3	1	2	3	1	2	3	4	5	TOTAL LANDINGS
1972		451	662	2461	701	-	-	59	149	652	-	1358	440	85	432	-	10	7	501	42	15	-	-	8025
1973		901	485	1097	604	203	-	26	79	163	-	970	951	275	547	233	3	5	306	4	30	18	-	6900
1974		766	1099	1213	478	-	111	115	149	200	341	874	1495	141	810	170	60	20	363	1	69	-	-	8475
1975		831	818	1399	164	-	72	189	43	491	232	836	1616	23	1171	273	18	26	227	9	101	-	-	8539
1976		866	651	954	1627	91	18	156	75	2524	238	881	1670	17	570	223	2	-	424	-	48	-	140	11175
1977		1330	1129	1758	44	16	26	311	7	13	325	1029	2240	-	410	237	-	5	294	3	49	-	-	9226
1978		992	26	1236	58	42	69	642	1	-	445	1079	1691	23	160	289	-	51	579	-	33	-	-	7414[3]

[1] GILL-NETS includes: set and drift nets.

[2] OTHERS includes: Midwater Otter trawls, Bottom Otter trawls, longliners, shrimp trawls, pair-seiners, boat dredges, and fixed gear.

[3] Provisional statistics ICNAF

Table 4. 4T Plaice total commercial catch (t) and total [1] effort for all months[2]

Year	Catch (t)	CPUE	Effective Effort (total hrs. fished)
		OTB1-2	
1972	270	.008	33,750
1973	485	.011	44,091
1974	1097	.029	37,828
1975	818	.020	40,900
1976	652	.025	26,080
1977	1115	.039	28,590
1978	344	.040	8,600
		OTB1-3	
1972	2459	.038	64,711
1973	1066	.030	35,533
1974	1213	.056	21,661
1975	1399	.044	34,975
1976	937	.063	14,873
1977	1688	.094	17,957
1978	1100	.170	6,471
		DSN-2	
1972	1327	.144	9,215
1973	862	.151	5,709
1974	874	.176	4,966
1975	836	.217	3,853
1976	881	.243	3,626
1977	1029	.192	5,359
1978	1079	.230	4,691
		DSN-3	
1972	440	.140	3,143
1973	951	.135	7,044
1974	1495	.155	9,645
1975	1616	.168	9,619
1976	1670	.177	9,435
1977	2240	.211	10,616
1978	1628	.163	9,988

[1] Total effort here is calculated as actual number of hours fished, that is, total hours fished for a plaice catch whether directed or not.

[2] ICNAF Statistical Bulletins 1972-1977 and ICNAF provisional statistics for 1978.

Table 5. Derivation of effort index.

	OTB1-2		OTB1-3		SDN-2		SDN-3					
	Catch t	CPUE	Catch t	CPUE	Catch t	CPUE	Catch t	CPUE	Total Catch (t) OTB1-2 OTB1-3 SDN-2 SDN-3	Total Catch all gears	Index*	Effort**
1972	270	.008	2459	.038	1327	.144	440	.140	4496	8294	0.620	13,381
1973	485	.011	1066	.030	862	.151	951	.135	3364	6905	0.633	10,918
1974	1097	.029	1213	.056	874	.176	1495	.155	4679	8485	0.952	8,916
1975	818	.020	1399	.044	836	.217	1616	.168	4669	8443	0.867	9,547
1976	652	.025	937	.063	881	.243	1670	.177	4140	11193	1.066	10,518
1977	1152	.039	1688	.094	1029	.192	2240	.211	6109	9230	1.305	7,075
1978	344	.040	1100	.170	1079	.230	1628	.163	4151	7414	1.476	5,024
AVE. CPUE		.025		.070		.193		.164				

* $\text{Index} = \dfrac{((\text{CPUE/AVE}) \times \text{CATCH})_{\text{OTB1-2}} + ((\text{CPUE/AVE}) \times \text{CATCH})_{\text{OTB1-3}} + ((\text{CPUE/AVE}) \times \text{CATCH})_{\text{SDN-2}} + ((\text{CPUE/AVE}) \times \text{CATCH})_{\text{SDN-3}}}{\text{Catch (OTB1-2 + OTB1-3 + SDN-2 + SDN-3)}}$

** $\text{Effort} = \dfrac{\text{Total Catch all gears}}{\text{INDEX}}$

Table 6. Numbers of Plaice per tow* in research cruises (1968-1978)

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	.00	.00	0.13	0.19	.22	.14	.07	.03	0.0	0.05	0.0
2	2.35	1.02	3.46	3.82	2.84	2.90	5.51	1.20	0.34	1.41	0.18
3	12.99	7.03	9.22	11.67	7.37	13.22	20.12	9.25	14.09	30.04	2.75
4	36.20	26.46	15.52	19.10	15.64	18.15	42.92	37.32	74.80	99.42	28.90
5	40.57	37.78	24.73	19.83	14.01	19.75	34.96	70.14	141.61	157.33	39.53
6	34.41	34.56	28.14	21.42	14.31	15.10	26.73	33.97	115.89	107.46	44.29
7	29.12	30.93	27.82	22.38	15.93	12.50	16.86	25.87	54.68	78.99	45.54
8	17.50	18.97	17.43	13.80	10.91	14.71	12.73	15.98	24.39	35.15	29.19
9	6.14	6.78	4.94	4.11	4.92	11.75	14.81	12.38	22.04	13.14	11.21
10	4.34	5.02	3.65	2.70	2.96	5.32	7.88	8.10	14.82	7.77	8.01
11	4.05	4.76	3.89	2.41	1.44	2.56	3.65	6.31	10.90	4.73	4.61
12	2.81	3.52	3.3	1.59	1.57	1.86	1.51	1.92	6.92	3.10	2.64
13	1.35	1.63	1.6	0.99	.74	1.36	1.15	1.11	4.47	1.9	2.98
14	.99	1.52	1.23	.88	.59	1.59	1.78	1.14	2.16	1.09	1.36
15	.59	.95	.96	.46	.32	.71	.96	.83	1.18	0.6	0.87
16+	1.35	2.31	1.61	1.24	.51	2.40	1.40	3.08	2.41	.92	1.59
Total	194.76	183.24	147.63	126.59	94.28	124.02	193.04	228.63	490.70	543.11	223.64

Table 7.

POPULATION NUMBERS $x10^3$ 4/ 6/79

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
6	65689	66257	65404	59264	55138	59624	53527	62263	46331	56352	57956	59605	97699	77599	94847
7	51475	50768	49380	47619	44123	40411	45286	44205	51559	38045	46821	48024	49257	78935	60271
8	34639	37801	35077	32725	33225	30036	27983	34923	33633	40396	29091	36259	36889	36165	58629
9	25233	25703	27087	24011	23260	23577	21554	20908	26600	25829	31905	21873	27724	27312	26489
10	17289	19122	18683	19411	17569	16850	17579	15774	14972	20168	19728	24694	15781	21311	20913
11	11794	12711	13583	12819	14118	12472	12235	11464	9586	9287	14053	13326	17234	11066	16290
12	6834	8625	8919	9398	9213	10288	9140	8092	7212	5856	5794	9665	8796	12869	8052
13	4100	4219	5219	5176	6104	5899	7117	6467	5441	4833	3778	3593	6784	5125	9423
14	2791	2641	2455	3158	3396	4170	4149	5220	4581	3795	3344	2350	2100	4537	3604
15	2043	1911	1623	1375	2133	2324	3076	2876	3736	3260	2639	2185	1260	1083	3501
16	1636	1476	1270	972	846	1491	1704	2073	1850	2651	2288	1699	1252	695	737
17	1165	1126	896	669	500	384	988	1021	1300	1155	1880	1526	974	677	490
18	863	849	766	541	393	243	170	177	146	458	387	948	575	492	515
19	612	636	589	499	339	208	97	93	94	74	346	280	757	279	329
20	404	421	408	348	303	163	68	77	73	74	57	291	233	397	191
21	257	264	251	225	200	159	53	53	61	58	59	44	245	27	285
	226824	234531	231611	218211	210859	208297	204727	215686	207174	212292	220126	226361	267562	278571	304565

Table 8. Catch at age 4T plaice.

	Year	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Age	6	6219	8243	9350	7422	7594	6502	2011	2189	1974	1813	2004	2205	5557	7026	8392
	7	7010	9291	10539	8366	8560	7329	4371	4757	4291	3940	4355	4791	6716	10036	5586
	8	4431	5872	6661	5287	5410	4632	3425	3727	3362	3087	3412	3754	4783	5000	5678
	9	2798	3708	4206	3339	3416	2925	2994	3258	2939	2698	2983	3282	2750	2796	2676
	10	2338	3099	3515	2790	2855	2444	3952	4301	3879	3562	3937	4332	2713	2212	2182
	11	1644	2179	2472	1962	2007	1719	2629	2861	2581	2370	2619	2882	2117	1587	1740
	12	1793	2376	2695	2139	2189	1874	1508	1642	1481	1360	1503	1653	2636	1782	1024
	13	956	1267	1438	1141	1168	1000	975	1061	957	879	972	1069	1403	869	1053
	14	528	700	794	630	645	552	749	815	735	675	746	821	781	435	385
	15	305	404	458	363	372	318	618	673	607	557	616	678	420	210	374
	16	304	402	456	362	371	317	479	522	471	432	478	525	431	117	113
	17	165	218	248	197	201	172	726	790	712	654	723	795	374	73	77
	18	115	152	173	137	140	120	57	62	56	51	57	62	233	101	83
	19	113	150	170	135	138	118	7	7	7	6	7	7	274	53	44
	20	90	119	135	107	110	94	5	5	5	5	5	6	187	62	27
	21+	42	55	63	50	51	44	12	13	12	11	12	13	111	11	171

Table 9.

FISHING MORTALITY 4/ 6/79

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
6	0.108	0.144	0.167	0.145	0.161	0.125	0.041	0.039	0.047	0.035	0.038	0.041	0.063	0.103	0.100
7	0.159	0.220	0.261	0.210	0.235	0.218	0.110	0.123	0.094	0.118	0.106	0.114	0.159	0.147	0.105
8	0.148	0.183	0.229	0.191	0.193	0.182	0.141	0.122	0.114	0.086	0.135	0.118	0.151	0.161	0.110
9	0.127	0.169	0.183	0.162	0.172	0.144	0.162	0.184	0.127	0.119	0.106	0.176	0.113	0.117	0.115
10	0.158	0.192	0.227	0.168	0.193	0.170	0.277	0.348	0.328	0.211	0.242	0.210	0.205	0.119	0.119
11	0.163	0.204	0.218	0.180	0.166	0.161	0.263	0.313	0.343	0.322	0.224	0.265	0.142	0.168	0.122
12	0.332	0.352	0.394	0.282	0.296	0.219	0.196	0.247	0.250	0.288	0.328	0.204	0.390	0.162	0.147
13	0.290	0.392	0.352	0.272	0.231	0.202	0.160	0.195	0.210	0.218	0.325	0.387	0.252	0.202	0.128
14	0.229	0.337	0.429	0.243	0.229	0.154	0.217	0.185	0.190	0.213	0.275	0.473	0.512	0.109	0.122
15	0.175	0.259	0.363	0.336	0.208	0.160	0.245	0.291	0.193	0.204	0.290	0.407	0.445	0.235	0.122
16	0.223	0.349	0.491	0.515	0.640	0.261	0.362	0.317	0.321	0.194	0.255	0.406	0.464	0.200	0.180
17	0.166	0.235	0.354	0.382	0.572	0.665	1.570	1.795	0.894	0.945	0.535	0.826	0.534	0.123	0.185
18	0.155	0.216	0.279	0.318	0.488	0.762	0.449	0.484	0.533	0.131	0.173	0.074	0.574	0.250	0.190
19	0.224	0.295	0.375	0.348	0.583	0.960	0.081	0.097	0.084	0.108	0.022	0.031	0.494	0.229	0.155
20	0.275	0.367	0.446	0.407	0.496	0.974	0.099	0.087	0.077	0.075	0.120	0.022	1.992	0.184	0.165
21	0.193	0.258	0.314	0.273	0.320	0.352	0.279	0.303	0.237	0.227	0.245	0.386	0.662	0.561	1.019
WF	0.149	0.195	0.227	0.188	0.200	0.171	0.145	0.152	0.139	0.123	0.131	0.142	0.141	0.134	0.111

WF is the weighted average of the fishing mortalities where the weighing is on the basis of population numbers.

Table 10.

YIELD PER RECRUIT

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
F0.1---	0.175	0.39109	0.173	0.442	1.000
	0.500	0.58927	0.194	0.329	0.392
	1.000	0.69721	0.198	0.285	0.201
	1.500	0.75175	0.201	0.267	0.136
	2.000	0.78644	0.203	0.258	0.103
	2.500	0.81091	0.204	0.252	0.083
	3.000	0.82929	0.205	0.248	0.069
	3.500	0.84372	0.207	0.245	0.060
	4.000	0.85543	0.208	0.243	0.053
	4.500	0.86518	0.209	0.241	0.047
	5.000	0.87347	0.210	0.240	0.042
	5.500	0.88064	0.210	0.239	0.039
	6.000	0.88693	0.211	0.238	0.036
	6.500	0.89250	0.212	0.237	0.033
	7.000	0.89750	0.213	0.237	0.031
	7.500	0.90201	0.213	0.236	0.029
	8.000	0.90611	0.214	0.236	0.027
	8.500	0.90987	0.214	0.235	0.025
	9.000	0.91333	0.214	0.235	0.024
	9.500	0.91652	0.215	0.234	0.023
	10.000	0.91949	0.215	0.234	0.022

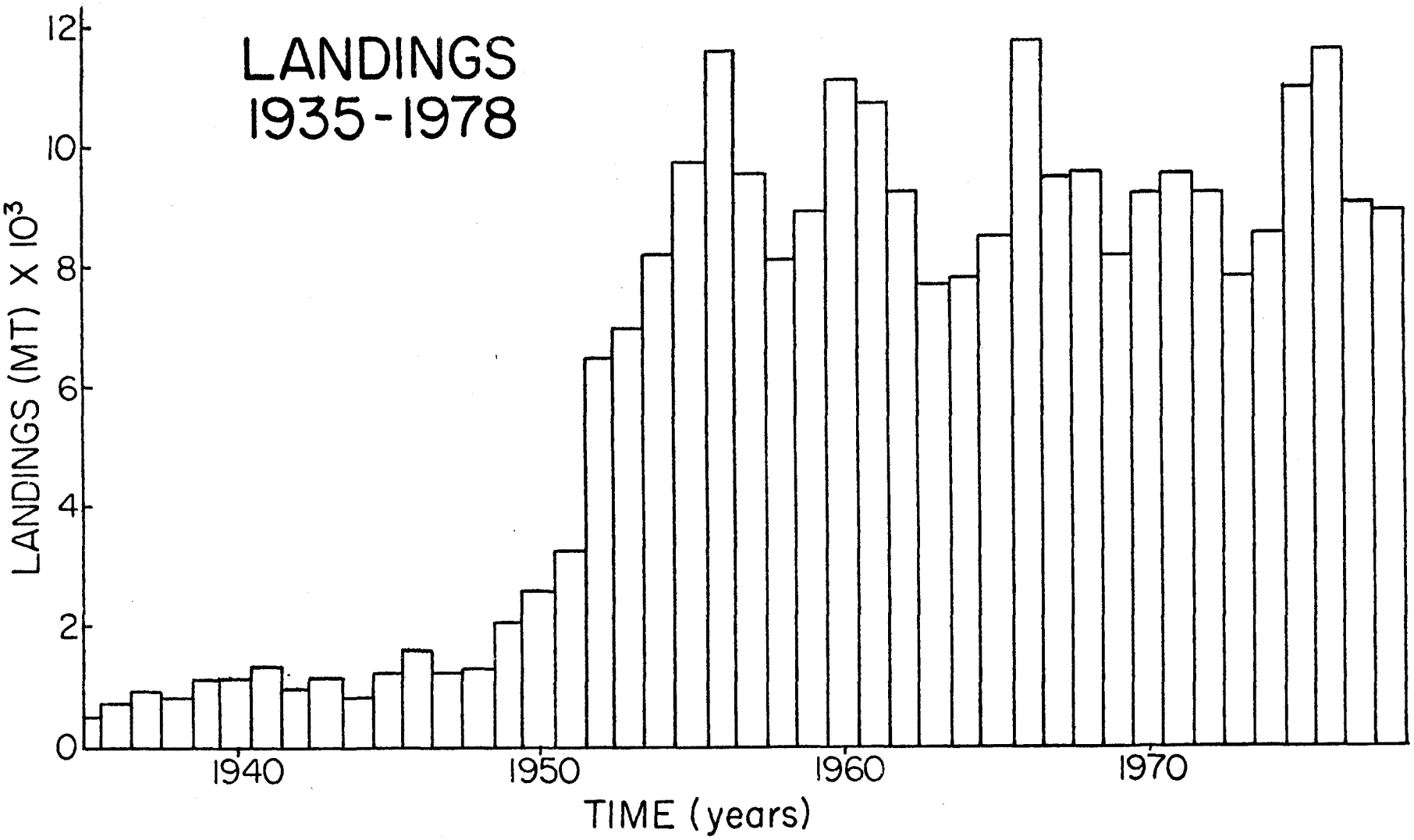

Figure 1. American Plaice landings in the Gulf of St. Lawrence 1935-1978.

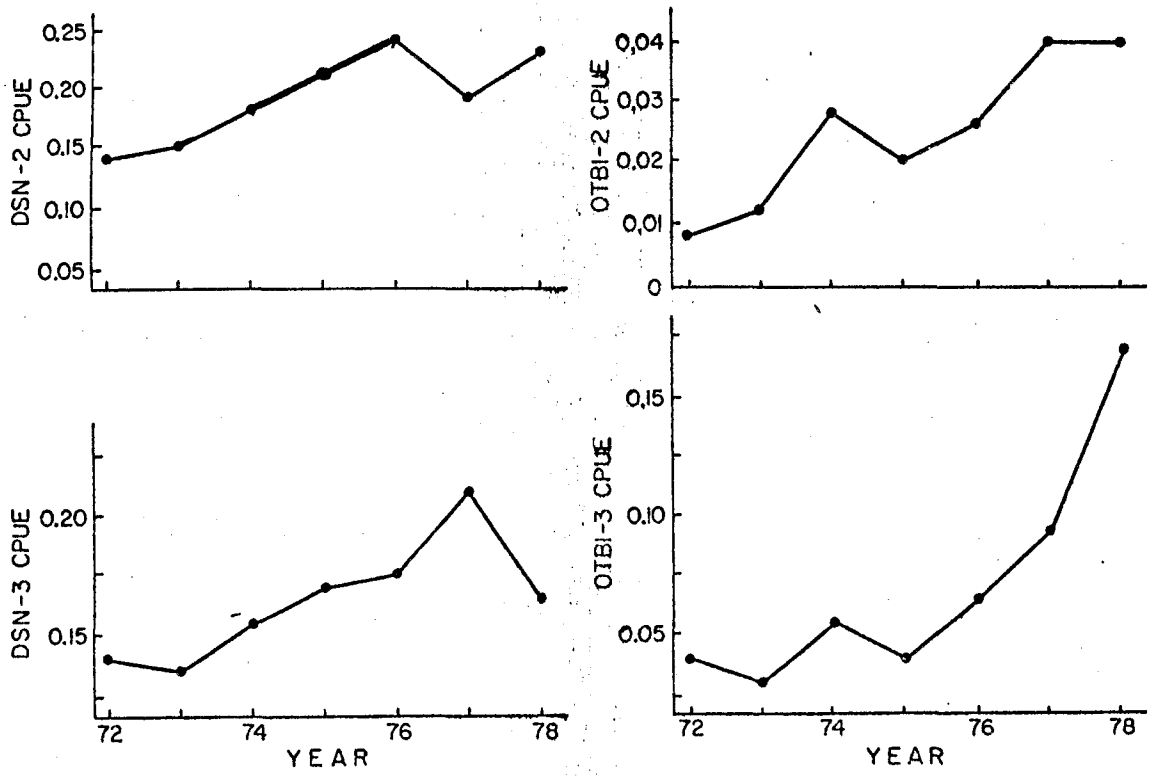

Figure 2. CPUE of the major gears, DSN 2 and 3, OTB1-2 and OTB1-3 where total effort was determined in hours fished during 1972-1978.

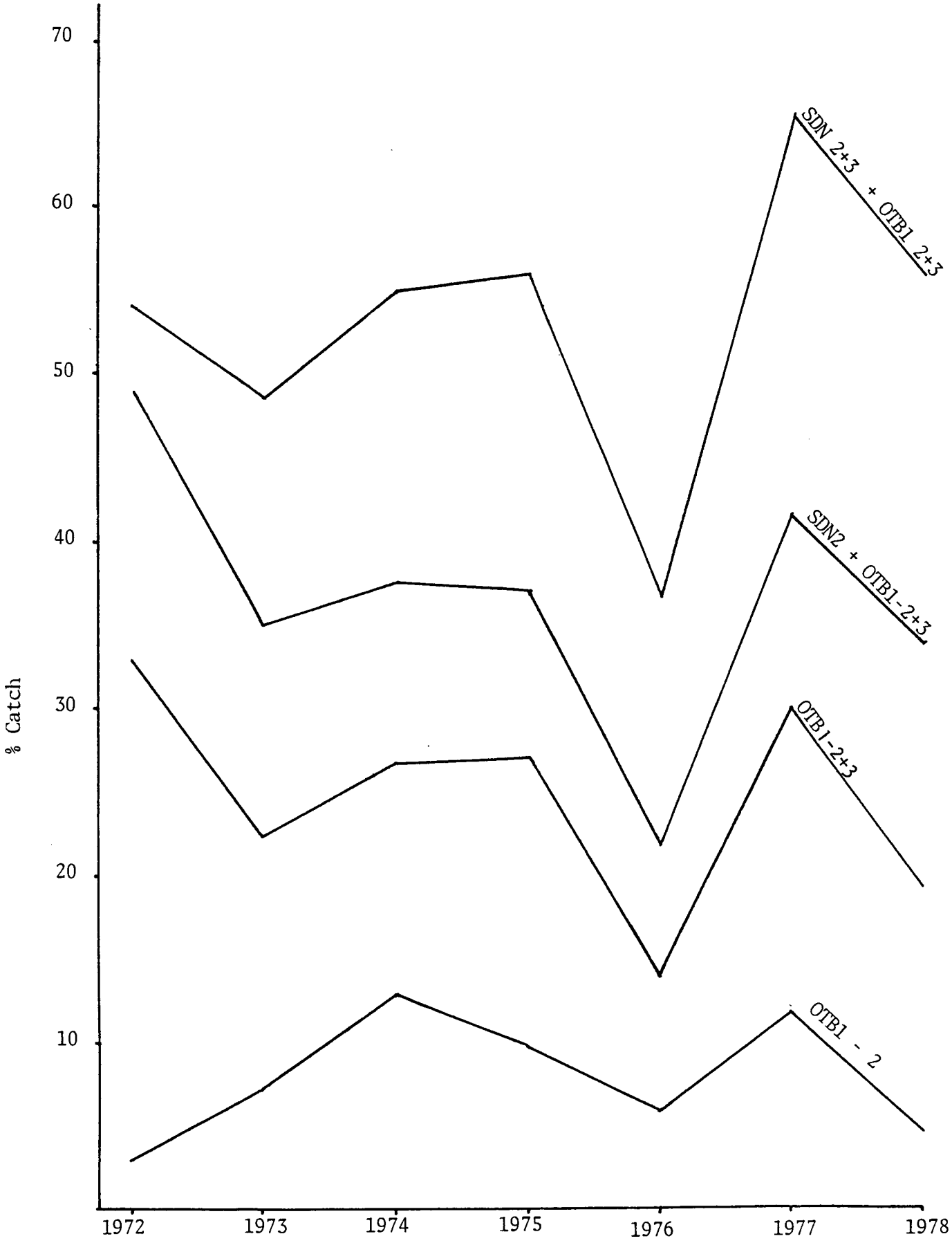

Figure 3. Cumulative catch distribution by gear

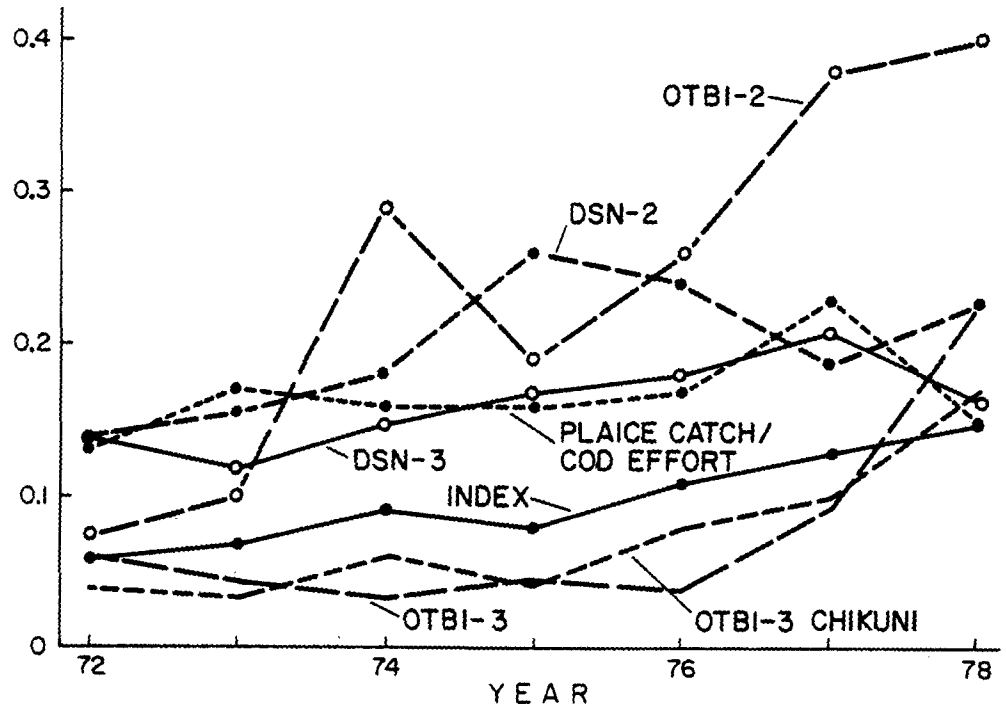

Figure 4. CPUE for various gears fishing American Plaice during 1972-78. CPUE Index combines OTB1-2 and 3 and SDN-2 and 3.

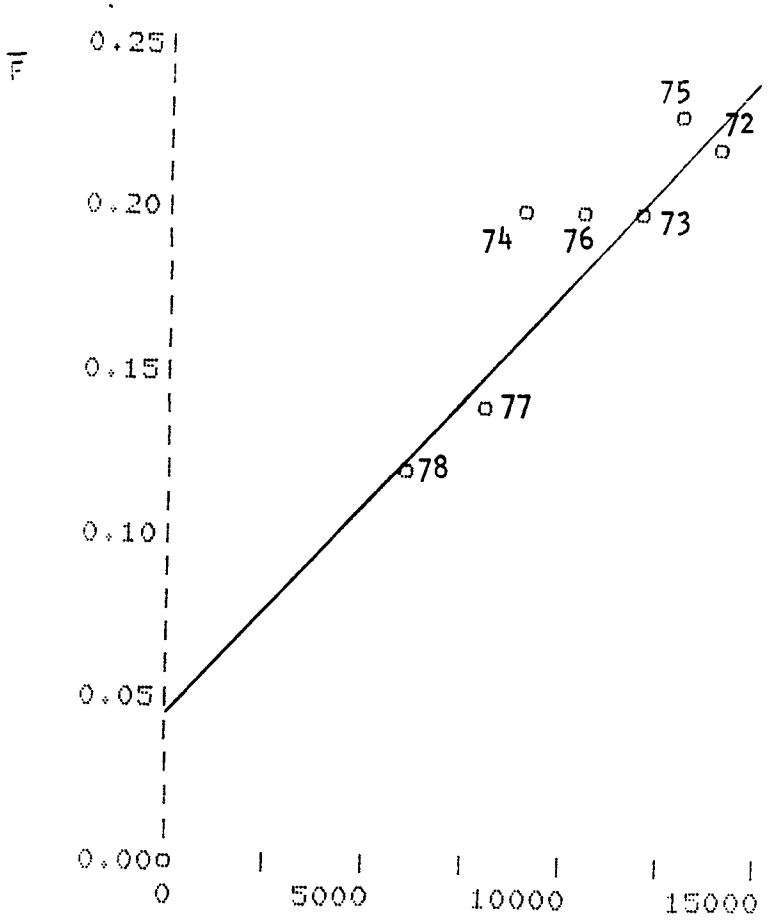

Fig. 5. Relationship between weighted F (by population) of the VPA the Effort Index (R^2 = 84.71), combining DSN-2-3 OTB1-2, 3 CPUE.

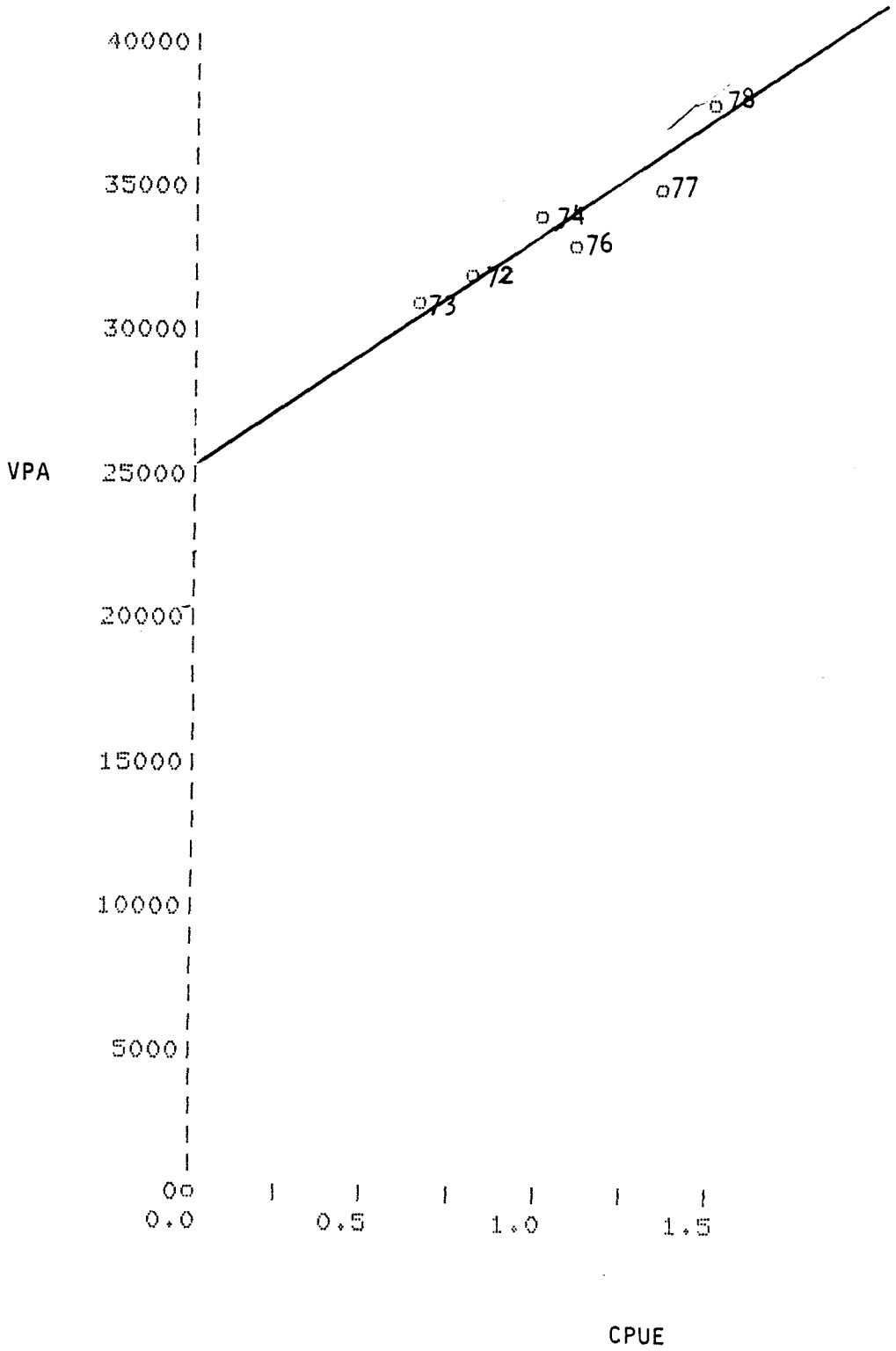

Fig. 6. Relationship between mature biomass of the VPA and CPUE index (R^2 = 91.58).

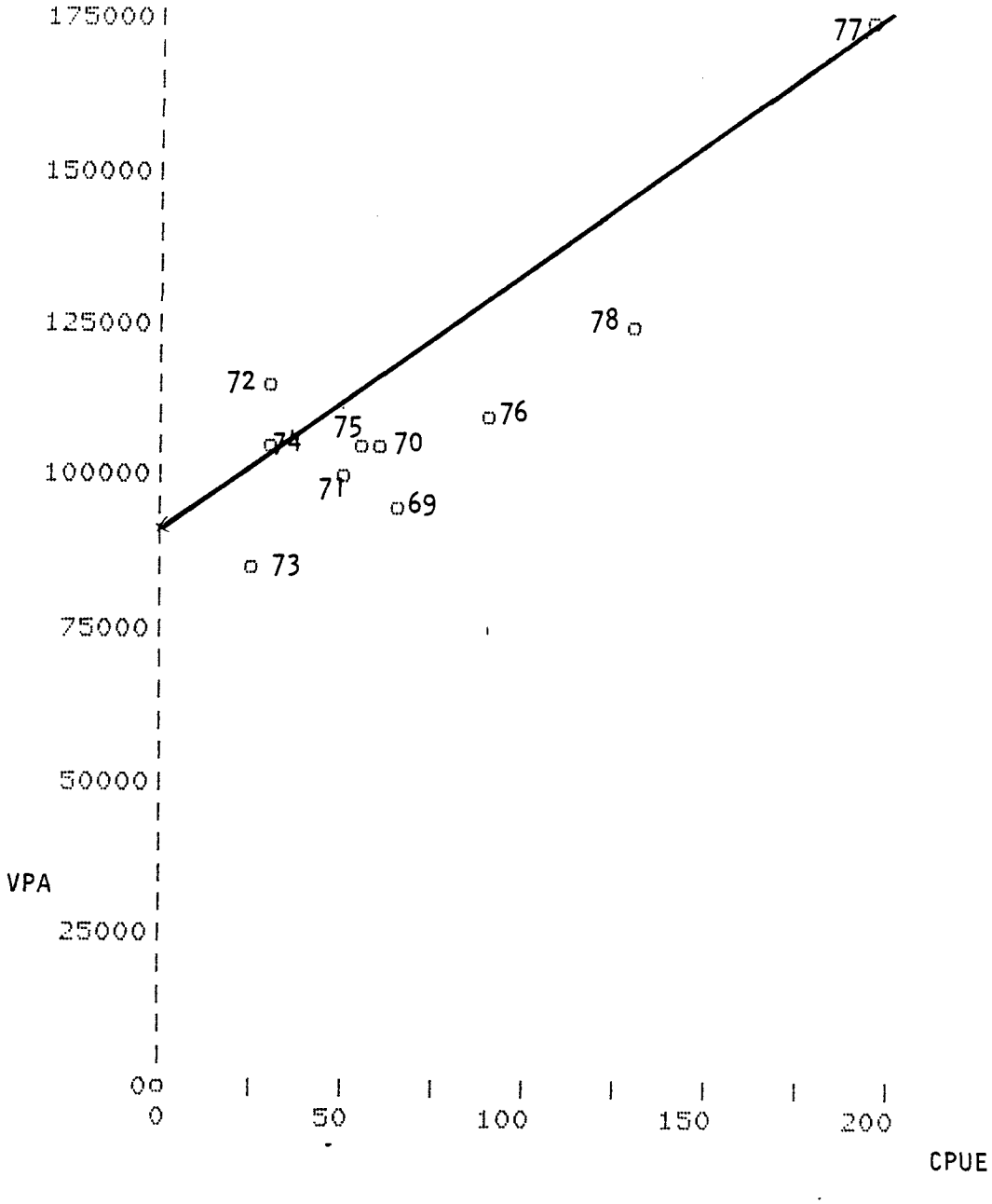

Fig. 7. Regression of population numbers (6+7 yr olds) of VPA and research CPUE (6+7 yr olds) R^2 = 81.99.