Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC
Research Document # 82/35

3P Redfish

by

D. B. Atkinson and C. A. Gavaris
Research and Resource Services
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland
A1C 5X1

Abstract

The 1981 provisional catch of 8500 t was up slightly from the 1980 nominal landing but still well below the TAC of 18,000 t. The multiplicative model, standardized to Newfoundland side trawlers TC 4 suggested fairly stable catch rates in recent years although these are below the long term average prior to 1974, suggesting that the stock is below historic levels. An analytical assessment was not conclusive in suggesting a terminal F due to the apparent low levels of F in recent years. There is some indication that new recruits are reaching ages 10+ and will contribute to the fishery in the future.

Résumé

Les statistiques préliminaires indiquent que les prises de 8 500 t en 1981 ont été légèrement supérieures au débarquement nominal de 1980, mais quand même bien inférieures au TPA de 18 000 t. Le modèle multiplicateur, standardisé par rapport aux chalutiers à pêche latérale de CT 4 de Terre-Neuve, laisse supposer des taux de capture récents assez stables, bien qu'au-dessous de la moyenne à long terme d'avant 1974, ce qui suggère des effectifs de stock inférieurs aux niveaux historiques. Le F de dernière année, découlant d'une évaluation analytique, n'a pas été concluant à cause des bas niveaux de F en ces dernières années. Il y a des indications que les nouvelles recrues atteignent les âges 10+ et qu'elles contribueront à la pêche dans les années à venir.

Introduction

In 1974 the first TAC was imposed on the 3P redfish stock at a level of 25,000 t. Poor recruitment in the mid-1960's resulted in a gradual lowering of the TAC to a low of 11,000 t in 1979 but with the recruitment of relatively strong year-classes of the early 1970's, more recent assessments (Atkinson et al. 1979, 1980, and 1981) have suggested an increased TAC. In 1979 the TAC was raised to 16,000 t for that year and it was set at 18,000 t for 1980, 1981, and 1982. The quotas were not achieved in 1979-81 primarily as a result of reduced effort.

Methods and Results

Trends in catch, effort and CPUE

Again in 1982, catch rates were standardized using the multiplicative model (Gavaris 1980). Canadian (Maritime and Newfoundland) vessels only were used. Maritime tonnage class 2 was omitted because of relatively few data points and Newfoundland tonnage classes 2 and 3 were omitted because the effort data do not come from logbooks but are estimated by Economics Branch. Only catches with $\geq$50% redfish were included and the data were weighted by effort. Category types which were grouped are as follows: Maritime OT 5 and Newfoundland MWT 4; Maritime MWT 4 and Newfoundland OT 5; February and March; May and October; and, November and December. The data were standardized to Nfld. OT 4, July and 3Ps.

Nominal catches, catch rates, and effort can be seen in Table 1 and Fig. 1-3. Catches rose from 3,900 t in 1959 to 37,000 t in 1970 but since then have generally declined to about 8,000 t in 1980 and 1981. In 1979-81 effort has dropped below that of previous years and is at a level similar to that of 1962-66. Catch rates peaked in 1964-65 but then showed a gradual decline. In recent years catch rates have levelled off but at the lowest levels recorded for the stock. The average CPUE for the period 1975-81 is 0.376 t/hr, well below the average from 1959-74 of 0.621 t/hr, suggesting that the stock biomass is below historic levels.

Numbers at age

Commercial length frequencies and age/length keys collected from the 1981 commercial fishery were applied to the total reported commercial catch by the method of Gavaris and Gavaris (unpublished)[1]. These were used along with the catch-at-age determined for previous years and the resulting catch matrix can be seen in Table 2.

Weight-at-age

The weights-at-age determined utilizing the technique above to derive numbers-at-age were input for 1981. For earlier years the same weights as used previously (Atkinson et al. 1981) were used. These can be seen in Table 3.

[1]Paper entitled "Estimation of catch-at-age and its variance for groundfish stocks in the Newfoundland Region" was presented to the DFO seminar on "Sampling of commercial marine fish and invertebrate catches", Ottawa, February, 1982.

Partial recruitment

This was determined as in the past by comparing the numbers caught at age (sexes combined) in the commercial fishery with the numbers-at-age (sexes combined) from research surveys for the years 1976-81. Fish aged 14+ were considered to be fully recruited. Because the surveys were variable in their coverage and their estimates of the population at age, the 6 years were averaged (geometric mean) then smoothed to obtain the partial recruitment vector shown in Table 3.

Terminal fishing mortality

Cohorts were run for a series of terminal F's from 0.025 to 0.10. At each F_T an initial run was carried out then the average F for ages 14-27 determined. These F's were then input at the oldest age group in each year and iterations carried out until the F's stabilized. The results of these cohort runs are shown in Tables 4-7.

Linear regressions of F (6+, 10+, 14+) on effort were carried out. In all cases the slopes were not significantly different from 'zero' and, therefore, this method was discarded and the results not presented.

Regressions of biomass (start of year) (6+, 10+, 14+) on CPUE (1973-80) were also carried out. The results are summarized in Table 8. It appeared that, as in 1981, the 10+ biomass was the best indicator with the intercept passing through the origin between F_T of 0.025 and 0.05 and the 1982 point falling on the regression line at F_T between 0.025 and 0.05. Regressions of mid-year biomass (10+) on CPUE (1973-80) were then run and the results shown in Table 8 and Fig. 4-7. The intercept passes through the origin between F_T of 0.025 and 0.05 while the 1981 point is closest to the regression line at F_T of 0.05.

The catch rates were standardized to that of 1973, multiplied by the 1973 mid-year biomass (10+), and compared with the mid-year biomass (10+) from cohort. These are shown in Fig. 8-10. The results indicate that an F_T of 0.05 results in the closest prediction of biomass from cohort although an F_T slightly below this would bring the two lines even closer in the most recent years.

In examining the regressions it was thought that the 1973 point may be exerting a great deal of influence in reducing the slope so the regressions were recalculated using only data from 1974-80. The results are summarized in Table 8 and are plotted in Fig. 11-14. The intercept passes through the origin between F_T of 0.025 and 0.050 while the 1981 point is closest to the line between F_T of 0.05 and 0.075. A comparison of catch rate ratios (standardized to 1974) X 1974 mid-year biomass (10+) (Fig. 15-16) gave the closest fit at $F_T = 0.025$ although the 1981 biomass from cohort was higher. At $F_T = 0.05$, the biomass from cohort was lower in all years.

Finally, the catch rates and 10+ mid-year biomass from 1973 to 1978 inclusive were averaged and these averages used for a comparison between ratios of catch rate and biomass from cohort. The results (Fig. 17-19) suggest a terminal F of 0.05 or slightly below.

As expected when dealing with such low values of terminal F, none of the above analyses result in accurate or consistent determinations of terminal F. It is also important to note that at these low levels of F, small changes in the values have great effects on the estimates of stock status.

Research cruise data

Again in 1981, the A. T. CAMERON research cruise (Fig. 20) indicated the presence of relatively strong year-classes (age 7-10) which are becoming available to the fishery. It is interesting to note that since 1979, research cruises have consistently suggested the relatively good strength of age 7-10 fish but there has been no indication of stronger year-classes moving through as older fish with time. This may reflect a number of things: a) a larger number of relatively strong year-classes are present and are first caught in quantity at ages 7-10, thus, masking increases in numbers at older ages or b) the research cruises are selective for fish of this size range for unknown reasons. In light of these, the presence of relatively large numbers of pre-recruit fish (age 7-10) should perhaps be viewed with caution.

In addition, in 1981 the research cruise indicated the presence of a large number of 2-yr-olds (1979 year-class). It is interesting to note that this year-class also appears to be quite strong in 4RST.

Commercial frequencies

The commercial length frequencies (Fig. 21-23) show a wide range of lengths (20-45 cm) in the catches in 3Ps for all months except June when smaller fish (20-35 cm) only were caught. In 3Pn in February smaller fish were caught (20-35 cm) while in July larger fish (30-45 cm) made up most of the catch. During other months, a wide range of sizes were taken. The only Maritime commercial frequency shows fish 33-47 cm being taken by midwater trawl in April.

References

Atkinson, D. B., W. D. McKone, and W. E. Legge. 1979. Assessment of 3P redfish. CAFSAC Res. Doc. 79/42.

1980. 3P redfish assessment. CAFSAC Res. Doc. 80/62.

Atkinson, D. B., W. E. Legge, and P. Stead. 1981. The redfish stock in NAFO Division 3P. CAFSAC Res. Doc. 81/59.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37: 2272-2275.

Thompson, W. F., and F. H. Bell. 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per recruit gear. Rept. Int. Fish. (Pacific Halibut) Comm. 8: 49 p.

Table 1. Commercial catch (t), standardized effort (hrs.), and CPUE (t/hr.) for 3P redfish, 1959-81.

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1959	3866	0.386	0.590	0.064	6553
1960	9225	0.530	0.511	0.030	18057
1961	9776	0.787	0.533	0.026	18346
1962	13439	0.606	0.459	0.020	29302
1963	13747	0.797	0.622	0.028	22116
1964	13807	0.810	0.630	0.028	21901
1965	18733	0.768	0.822	0.035	22793
1966	20868	0.695	0.919	0.042	22715
1967	32991	0.342	0.784	0.038	42071
1968	13884	0.401	0.724	0.045	19178
1969	32784	0.221	0.723	0.040	45337
1970	37270	0.258	0.634	0.030	58740
1971	27500	0.151	0.537	0.034	51220
1972	26037	0.170	0.459	0.028	56755
1973	18368	0.712	0.542	0.025	33887
1974	22158	0.359	0.449	0.023	49360
1975	28445	0.596	0.434	0.019	65590
1976	19167	0.805	0.387	0.016	49574
1977	17163	0.819	0.374	0.014	45835
1978	15245	0.908	0.365	0.013	41823
1979	9619	0.862	0.345	0.014	27879
1980	7561	0.791	0.364	0.016	20795
1981*	8505	0.703	0.361	0.017	23548

Average C.V. for the mean: 0.051

* Provisional

Table 2. 3P redfish catch-at-age, 1973-81, (sexes combined, numbers X 10^{-3}).

3P REDFISH CATCH-AT-AGE, 1973-1981

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	13	105	401	41	257	1339	440	191	8
7	11	895	694	56	491	4146	1510	976	194
8	16	1876	1868	263	499	7359	2703	1775	1474
9	8	1647	883	581	790	7382	2859	2376	1829
10	20	1528	486	386	835	5203	1606	1928	1604
11	536	1830	1112	434	777	2358	896	1531	1278
12	1004	1399	623	506	971	2049	1020	1219	1176
13	3076	3602	1016	990	849	857	714	629	1262
14	6099	3058	1123	1119	1022	1085	710	802	604
15	9314	3173	2206	1072	1438	1162	496	579	493
16	5866	7661	3613	1796	793	927	449	313	365
17	7300	2597	8428	1124	1298	791	603	366	331
18	1842	3930	6040	4154	1005	1067	548	308	289
19	878	1063	12060	1897	2659	852	531	315	380
20	1149	1326	3015	6345	1490	1883	655	319	356
21	589	701	2323	1463	4659	520	1021	428	272
22	385	1555	2080	2387	2281	1534	676	809	485
23	404	2821	1758	1957	2398	1040	1263	484	833
24	484	1410	790	1310	2031	1080	731	796	496
25	168	2147	1205	2269	1083	1053	1053	482	971
26	2	1887	995	1613	619	674	691	490	654
27	2	2	687	868	396	532	454	239	617
28	2	2	2	575	307	339	345	287	428
29	2	2	2	2	289	187	207	171	353

Table 3. Average weight-at-age and partial recruitment used in cohort analyses and projections (sexes combined).

Age	Weight-at-age (grams)		Partial Recruitment
	[1]	[2]	
6	105.	113.	.014
7	142.	137.	.030
8	177.	177.	.071
9	213.	220.	.153
10	247.	266.	.268
11	286.	290.	.434
12	331.	340.	.642
13	369.	355.	.891
14	406.	417.	1.000
15	445.	426.	1.000
16	481.	465.	1.000
17	516.	515.	1.000
18	553.	541.	1.000
19	587.	621.	1.000
20	621.	625.	1.000
21	657.	601.	1.000
22	688.	650.	1.000
23	724.	652.	1.000
24	770.	707.	1.000
25	816.	726.	1.000
26	865.	784.	1.000
27	913.	811.	1.000
28	948.	872.	1.000
29	985.	883.	1.000

NATURAL MORTALITY RATE IS .100

[1] Used in all years prior to 1981.

[2] Used in 1981 and projections.

Table 4a. F_T=0.025, population numbers from cohort (X 10^{-3})

POPULATION NUMBERS

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	70158	135631	158180	222305	388469	684990	1068366	300714	24023
7	58396	63469	122624	142746	201111	351257	618531	966279	271916
8	43330	52828	56578	110295	129109	181506	313887	558234	873397
9	40101	39192	46017	49417	99548	116348	157233	281445	503422
10	36972	36277	33895	40798	44162	89324	98254	139551	252402
11	46737	33435	31371	30208	36548	39165	75874	87376	124437
12	46249	41780	28513	27328	26920	32331	33195	67802	77605
13	43504	40892	36473	25207	24246	23435	27305	29066	60190
14	67476	36438	33575	32036	21866	21131	20389	24028	25701
15	125397	55253	30062	29311	27923	18813	18088	17774	20978
16	72161	104605	46977	25103	25502	23898	15918	15895	15532
17	142755	59714	87363	39070	21005	22321	20742	13976	14085
18	78854	122226	51561	71032	34283	17772	19445	18194	12298
19	75952	69598	106856	40909	60321	30064	15066	17073	16170
20	54842	67889	61964	85216	35212	52051	26393	13127	15149
21	44316	48530	60167	53199	71071	30443	45307	23258	11574
22	27880	39538	43245	52232	46745	59876	27052	40024	20638
23	21459	24861	34296	37151	44990	40127	52719	23834	35446
24	14911	19033	19811	29360	31754	38428	35319	46500	21106
25	12840	13031	15880	17175	25320	26801	33744	31263	41318
26	56	11458	9749	13223	13382	21881	23249	29531	27829
27	36	48	8573	7875	10430	11520	19157	20379	26255
28	46	31	42	7104	6300	9061	9917	16902	18212
29	42	40	26	36	5881	5408	7876	8645	15021
6+	1124470	1115798	1123799	1188334	1432099	1947950	2783025	2790870	2524703
7+	1054312	980167	965618	966028	1043630	1262960	1714658	2490156	2500680
8+	995916	916697	842994	823282	842518	911702	1096127	1523877	2228764
9+	952586	863869	786416	712987	713409	730196	782240	965643	1355366
10+	912485	824677	740399	663570	613861	613849	625007	684198	851944
11+	875513	788400	706504	622773	569699	524525	526753	544646	599542
12+	828776	754965	675133	592565	533151	485360	450879	457270	475105
13+	782527	713186	646620	565237	506231	453029	417684	389469	397500
14+	739023	672294	610147	540031	481985	429594	390379	360403	337310

Table 4b. F_T=0.025, mid-year biomass from cohort (t).

POPULATION BIOMASS (MID-YEAR)

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	7010	13547	15785	22211	38803	68376	106729	30038	2583
7	7890	8514	16522	19285	27142	47175	83477	130506	35437
8	7297	8734	9366	18555	21703	29927	52635	93873	146985
9	8127	7770	9235	9956	20095	22801	31570	56799	105197
10	8688	8340	7908	9543	10279	20357	22899	32567	63681
11	12645	8840	8381	8160	9837	10324	20524	23565	34159
12	14404	12931	8879	8525	8320	9846	10289	21158	24912
13	14711	13695	12622	8670	8359	8072	9458	10092	20113
14	24832	13458	12746	12152	8242	7946	7735	9122	10075
15	51036	22697	12241	12176	11507	7710	7551	7399	8401
16	31622	46044	20636	11060	11485	10718	7179	7201	6789
17	68228	28658	40721	18898	9981	10758	10031	6769	6819
18	40994	63246	25455	36239	17766	9059	10083	9491	6254
19	42173	38570	56134	22300	32922	16547	8261	9446	9439
20	32057	39713	35689	48394	20350	30181	15396	7660	8900
21	27516	30115	36861	32786	42911	18865	27995	14403	6539
22	18123	25356	27603	33382	29826	38680	17481	25930	12610
23	14640	16102	22998	24893	30135	27274	35870	16248	21725
24	10741	13405	14215	21014	22490	27747	25602	33771	14027
25	9903	9230	11841	12403	19224	20386	25778	24082	28198
26	45	8603	7593	10182	10750	17723	18842	24100	20509
27	31	41	7135	6444	8883	9768	16440	17598	20015
28	41	27	37	6136	5539	8015	8785	15114	14929
29	39	36	23	33	5371	4978	7282	8021	12468
6+	452791	437671	420626	413397	431920	483233	587893	634951	640763
7+	445782	424124	404842	391186	393117	414858	481164	604913	638180
8+	437891	415610	388320	371901	365975	367682	397687	474407	602743
9+	430594	406876	378953	353346	344272	337755	345052	380534	455758
10+	422467	399106	369719	343390	324176	314955	313482	323735	350561
11+	413779	390766	361811	333848	313898	294598	290583	291168	286879
12+	401134	381926	353430	325687	304061	284274	270059	267604	252721
13+	386730	368996	344551	317162	295740	274427	259770	246446	227809
14+	372020	355301	331929	308492	287381	266355	250312	236354	207696

Table 4c. F_T = 0.025, fishing mortalities from cohort.

FISHING MORTALITY

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	0.000	0.001	0.003	0.000	0.001	0.002	0.000	0.001	0.000
7	0.000	0.015	0.006	0.000	0.003	0.012	0.003	0.001	0.001
8	0.000	0.038	0.035	0.003	0.004	0.044	0.009	0.003	0.002
9	0.000	0.045	0.020	0.012	0.008	0.069	0.019	0.009	0.004
10	0.001	0.045	0.015	0.010	0.020	0.063	0.017	0.015	0.007
11	0.012	0.059	0.038	0.015	0.023	0.065	0.012	0.019	0.011
12	0.023	0.036	0.023	0.020	0.039	0.069	0.033	0.019	0.016
13	0.077	0.097	0.030	0.042	0.038	0.039	0.028	0.023	0.022
14	0.100	0.092	0.036	0.037	0.050	0.055	0.037	0.036	0.025
15	0.081	0.062	0.080	0.039	0.056	0.067	0.029	0.035	0.025
16	0.089	0.080	0.084	0.078	0.033	0.042	0.030	0.021	0.025
17	0.055	0.047	0.107	0.031	0.067	0.038	0.031	0.028	0.025
18	0.025	0.034	0.131	0.063	0.031	0.065	0.030	0.018	0.025
19	0.012	0.016	0.126	0.050	0.047	0.030	0.038	0.020	0.025
20	0.022	0.021	0.053	0.082	0.046	0.039	0.026	0.026	0.025
21	0.014	0.015	0.041	0.029	0.071	0.018	0.024	0.020	0.025
22	0.015	0.042	0.052	0.049	0.053	0.027	0.027	0.021	0.025
23	0.020	0.127	0.055	0.057	0.058	0.028	0.026	0.022	0.025
24	0.035	0.081	0.043	0.048	0.070	0.030	0.022	0.018	0.025
25	0.014	0.190	0.083	0.150	0.046	0.042	0.033	0.016	0.025
26	0.038	0.190	0.113	0.137	0.050	0.033	0.032	0.018	0.025
27	0.060	0.044	0.088	0.123	0.041	0.050	0.025	0.012	0.025
28	0.047	0.070	0.051	0.089	0.053	0.040	0.037	0.018	0.025
29	0.051	0.054	0.084	0.060	0.053	0.037	0.028	0.021	0.025

Table 5a. F_T=0.05, population numbers from cohort (X 10^{-3})

POPULATION NUMBERS

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	41910	75691	88036	120272	200820	345855	535447	150513	12014
7	35339	37909	68388	79277	108787	181465	311669	484074	136008
8	26260	31966	33450	61220	71679	97968	160252	280573	437080
9	24620	23746	27139	28490	55144	64383	81645	142431	252185
10	23456	22270	19919	23717	25226	49145	51234	71156	126617
11	28965	21205	18697	17561	21092	22031	39519	44831	62550
12	29599	25699	17446	15860	15477	18346	17692	34906	39109
13	30783	25827	21922	15194	13869	13081	14651	15038	30424
14	44793	24928	19943	18870	12806	11742	11021	12578	13009
15	86439	34729	19647	16977	16010	10615	9592	9297	10618
16	48964	69354	28406	15679	14342	13118	8500	8208	7861
17	97342	38724	55466	22266	12478	12223	10988	7264	7129
18	48267	81135	32569	42171	19078	10056	10307	9369	6224
19	47095	41922	69676	23724	34206	16306	8084	8805	8184
20	34825	41778	36921	51573	19662	28422	13944	6810	7667
21	27806	30418	36541	30540	40630	16374	23926	11994	5858
22	19265	24600	26857	30854	26242	32332	14321	20678	10446
23	14644	17065	20780	22322	25647	21575	27796	12315	17941
24	10920	12866	12758	17130	18337	20926	18533	23949	10683
25	9013	9420	10301	10792	14254	14660	17907	16074	20913
26	36	7995	6481	8174	7607	11867	12263	15201	14086
27	25	31	5439	4918	5862	6294	10097	10439	13289
28	31	20	26	4268	3624	4927	5189	8704	9218
29	28	26	17	21	3315	2987	4136	4367	7603
6+	730425	699323	676825	681870	786195	1026698	1418712	1409572	1266714
7+	688515	623632	588789	561598	585375	680843	883265	1259059	1254700
8+	653176	585723	520401	482322	476588	499378	571597	774985	1118692
9+	626917	553758	486951	421102	404909	401410	411344	494412	681612
10+	602296	530012	459812	392612	349765	337027	329700	351981	429428
11+	578840	507743	439893	368895	324539	287883	278465	280825	302811
12+	549875	486538	421196	351334	303446	265851	238947	235994	240261
13+	520277	460839	403749	335474	287969	247505	221255	201089	201152
14+	489494	435012	381827	320280	274100	234424	206603	186051	170728

Table 5b. $F_{T=0.05}$, mid-year biomass from cohort (t).

POPULATION BIOMASS (MID-YEAR)

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	4187	7558	8776	12016	20053	34489	53480	15029	1291
7	4775	5060	9193	10709	14666	24231	42010	65345	17719
8	4422	5219	5470	10289	12030	15852	26756	47104	73492
9	4990	4638	5408	5714	11094	12260	16248	28621	52599
10	5511	5046	4623	5528	5827	10907	11847	16490	31841
11	7808	5510	4930	4718	5631	5658	10629	11985	17079
12	9159	7865	5393	4913	4715	5438	5405	10795	12456
13	10241	8398	7512	5153	4714	4436	5014	5166	10056
14	16057	9006	7479	7065	4741	4316	4115	4698	5037
15	34524	14000	7827	6952	6460	4236	3953	3809	4200
16	20993	29895	12127	6742	6375	5782	3783	3682	3394
17	45920	18348	25034	10646	5791	5799	5241	3473	3409
18	24896	41619	15436	21042	9764	4996	5274	4846	3127
19	26053	23109	35320	12696	18329	8860	4361	4827	4720
20	20227	24282	20884	28494	11158	16214	8039	3926	4450
21	17194	18791	22087	18617	23864	10068	14627	7360	3269
22	12482	15574	16870	19381	16397	20644	9145	13263	6305
23	9945	10721	13681	14671	16802	14491	18697	8311	10862
24	7817	8883	9046	12049	12651	14920	13301	17245	7013
25	6931	6413	7504	7431	10628	10955	13478	12287	14099
26	29	5740	4899	6015	5994	9479	9797	12303	10255
27	20	26	4410	3870	4913	5226	8567	8962	10008
28	27	17	22	3575	3124	4285	4519	7718	7464
29	26	23	14	19	2965	2709	3776	4010	6234
6+	294232	275740	253945	238305	238686	256251	302059	321255	320381
7+	290045	268182	245169	226290	218633	221763	248580	306225	319090
8+	285270	263123	235976	215581	203967	197532	206569	240880	301371
9+	280849	257903	230506	205292	191937	181680	179813	193776	227879
10+	275859	253265	225098	199578	180843	169420	163565	165155	175280
11+	270348	248219	220476	194051	175015	158513	151719	148665	143440
12+	262540	242709	215545	189333	169385	152855	141090	136680	126360
13+	253382	234844	210152	184420	164670	147417	135685	125885	113904
14+	243141	226446	202640	179266	159955	142981	130671	120720	103848

Table 5c. F_T = 0.05, fishing mortalities from cohort.

FISHING MORTALITY

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	0.000	0.001	0.005	0.000	0.001	0.004	0.001	0.001	0.001
7	0.000	0.025	0.011	0.001	0.005	0.024	0.005	0.002	0.002
8	0.001	0.064	0.061	0.005	0.007	0.082	0.018	0.007	0.004
9	0.000	0.076	0.035	0.022	0.015	0.128	0.038	0.018	0.008
10	0.001	0.075	0.026	0.017	0.035	0.118	0.034	0.029	0.013
11	0.020	0.095	0.065	0.026	0.039	0.119	0.024	0.037	0.022
12	0.036	0.059	0.038	0.034	0.068	0.125	0.063	0.037	0.032
13	0.111	0.159	0.050	0.071	0.067	0.071	0.053	0.045	0.045
14	0.154	0.138	0.061	0.064	0.088	0.102	0.070	0.069	0.050
15	0.120	0.101	0.126	0.069	0.099	0.122	0.056	0.068	0.050
16	0.135	0.123	0.144	0.128	0.060	0.077	0.057	0.041	0.050
17	0.082	0.073	0.174	0.055	0.116	0.070	0.059	0.054	0.050
18	0.041	0.052	0.217	0.109	0.057	0.118	0.058	0.035	0.050
19	0.020	0.027	0.201	0.088	0.085	0.056	0.072	0.038	0.050
20	0.035	0.034	0.090	0.139	0.083	0.072	0.051	0.051	0.050
21	0.023	0.025	0.069	0.052	0.128	0.034	0.046	0.038	0.050
22	0.021	0.069	0.085	0.085	0.096	0.051	0.051	0.042	0.050
23	0.029	0.191	0.093	0.097	0.103	0.052	0.049	0.042	0.050
24	0.048	0.122	0.067	0.084	0.124	0.056	0.042	0.036	0.050
25	0.020	0.274	0.131	0.250	0.083	0.079	0.064	0.032	0.050
26	0.060	0.285	0.176	0.232	0.089	0.062	0.061	0.034	0.050
27	0.089	0.071	0.142	0.205	0.074	0.093	0.048	0.024	0.050
28	0.070	0.109	0.085	0.153	0.093	0.075	0.072	0.035	0.050
29	0.077	0.084	0.136	0.103	0.096	0.068	0.054	0.042	0.050

Table 6a. F_T=0.075, population numbers from cohort (X 10^{-3})

POPULATION NUMBERS

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	32496	55714	64656	86262	138271	232810	357807	100446	8010
7	27655	29391	50312	58122	78014	124868	209382	323339	90705
8	20571	25013	25743	44864	52537	70123	109041	188020	291641
9	19461	18598	20848	21516	40345	47063	56450	96094	168439
10	18952	17601	15261	18024	18916	35754	35563	48358	84689
11	23042	17129	14473	13347	15942	16321	27402	30651	41922
12	24050	20339	13758	12038	11664	13685	12525	23942	26278
13	26543	20806	17073	11857	10411	9630	10434	10363	20504
14	37234	21092	15400	14482	9787	8613	7899	8762	8779
15	73455	27889	16176	12866	12039	7883	6761	6472	7165
16	41233	57605	22217	12538	10622	9526	6028	5646	5305
17	82208	31729	44836	16666	9636	8857	7737	5027	4811
18	38074	67441	26239	32553	14011	7485	7262	6428	4200
19	37478	32698	57284	17997	25503	11721	5757	6049	5523
20	28154	33077	28576	40361	14480	20547	9796	4704	5174
21	22304	24382	28668	22988	30485	11684	16801	8240	3953
22	16582	19621	21395	23730	19409	23152	10078	14231	7049
23	12386	14638	16275	17380	19201	15392	19490	8476	12107
24	9531	10823	10561	13054	13865	15093	12938	16434	7209
25	7780	8163	8452	8805	10566	10614	12629	11012	14113
26	29	6879	5344	6502	5809	8530	8602	10426	9505
27	21	25	4430	3889	4349	4667	7077	7126	8967
28	26	17	20	3355	2693	3558	3717	5972	6221
29	24	21	13	17	2489	2145	2897	3035	5131
6+	599287	560692	528011	513211	571041	719722	964071	949250	847400
7+	566792	504979	463355	426949	432771	486912	606264	848804	839389
8+	539137	475588	413043	368827	354757	362044	396883	525465	748684
9+	518566	450575	387300	323963	302219	291921	287841	337445	457043
10+	499106	431977	366453	302447	261875	244858	231392	241352	288604
11+	480154	414376	351191	284423	242959	209104	195829	192994	203915
12+	457112	397247	336718	271077	227017	192783	168427	162343	161993
13+	433062	376907	322960	259039	215354	179097	155902	138401	135715
14+	406518	356101	305887	247182	204943	169467	145468	128038	115211

Table 6b. F_T = 0.075, mid-year biomass from cohort (^{t}).

POPULATION BIOMASS (MID-YEAR)

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	3246	5562	6440	8617	13803	23193	35730	10027	861
7	3736	3909	6750	7850	10508	16582	28188	43625	11812
8	3463	4047	4171	7534	8806	11158	18130	31515	48995
9	3944	3594	4133	4300	8095	8743	11140	19228	35066
10	4452	3949	3528	4190	4344	7754	8162	11131	21227
11	6195	4399	3780	3571	4228	4101	7331	8125	11386
12	7411	6176	4231	3709	3513	3967	3777	7341	8304
13	8750	6630	5809	3981	3499	3224	3533	3524	6704
14	13129	7521	5723	5369	3573	3106	2908	3222	3358
15	29018	11101	6354	5210	4776	3077	2753	2612	2800
16	17448	24509	9287	5302	4672	4137	2651	2509	2263
17	38484	14911	19797	7895	4394	4145	3644	2374	2273
18	19531	34410	12088	15973	7096	3641	3670	3298	2085
19	20681	17957	28370	9495	13463	6298	3060	3287	3146
20	16284	19139	15948	21854	8093	11557	5586	2681	2967
21	13754	15016	17161	13894	17509	7136	10170	5012	2180
22	10726	12313	13291	14713	11918	14633	6367	9040	4203
23	8389	9042	10574	11263	12355	10230	12973	5665	7242
24	6799	7384	7436	9060	9369	10645	9201	11738	4676
25	5973	5430	6066	5878	7761	7811	9378	8356	9399
26	23	4814	3960	4630	4513	6731	6782	8372	6836
27	17	21	3531	2972	3597	3811	5943	6083	6672
28	22	14	18	2749	2284	3049	3189	5252	4976
29	21	19	11	15	2190	1919	2614	2761	4156
6+	241497	221866	198459	180024	174360	180646	206880	216779	213588
7+	238251	216304	192019	171407	160557	157453	171151	206753	212727
8+	234515	212396	185269	163556	150049	140871	142962	163128	200914
9+	231051	208348	181097	156023	141243	129713	124832	131613	151919
10+	227107	204754	176965	151723	133149	120970	113692	112385	116854
11+	222655	200805	173437	147533	128805	113216	105530	101254	95626
12+	216460	196406	169657	143962	124576	109115	98199	93130	84240
13+	209049	190230	165425	140253	121063	105148	94422	85788	75936
14+	200299	183600	159616	136272	117563	101924	90889	82265	69232

Table 6c. F_T = 0.075, fishing mortalities from cohort.

FISHING MORTALITY

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	0.000	0.002	0.007	0.000	0.002	0.006	0.001	0.002	0.001
7	0.000	0.033	0.015	0.001	0.007	0.036	0.008	0.003	0.002
8	0.001	0.082	0.079	0.006	0.010	0.117	0.026	0.010	0.005
9	0.000	0.098	0.046	0.029	0.021	0.180	0.055	0.026	0.011
10	0.001	0.096	0.034	0.023	0.048	0.166	0.049	0.043	0.020
11	0.025	0.119	0.084	0.035	0.053	0.165	0.035	0.054	0.033
12	0.045	0.075	0.049	0.045	0.092	0.171	0.089	0.055	0.048
13	0.130	0.201	0.065	0.092	0.090	0.098	0.075	0.066	0.067
14	0.189	0.165	0.080	0.085	0.116	0.142	0.099	0.101	0.075
15	0.143	0.127	0.155	0.092	0.134	0.168	0.080	0.099	0.075
16	0.162	0.151	0.187	0.163	0.082	0.108	0.082	0.060	0.075
17	0.098	0.090	0.220	0.074	0.153	0.099	0.085	0.080	0.075
18	0.052	0.063	0.277	0.144	0.078	0.162	0.083	0.052	0.075
19	0.025	0.035	0.250	0.117	0.116	0.079	0.102	0.056	0.075
20	0.044	0.043	0.118	0.181	0.114	0.101	0.073	0.074	0.075
21	0.028	0.031	0.089	0.069	0.175	0.048	0.066	0.056	0.075
22	0.025	0.087	0.108	0.112	0.132	0.072	0.073	0.062	0.075
23	0.035	0.226	0.121	0.126	0.141	0.074	0.071	0.062	0.075
24	0.055	0.147	0.082	0.111	0.167	0.078	0.061	0.052	0.075
25	0.023	0.324	0.162	0.316	0.114	0.110	0.092	0.047	0.075
26	0.074	0.340	0.218	0.302	0.119	0.087	0.088	0.051	0.075
27	0.108	0.089	0.178	0.267	0.101	0.128	0.070	0.036	0.075
28	0.086	0.135	0.108	0.199	0.128	0.106	0.103	0.052	0.075
29	0.093	0.104	0.173	0.135	0.130	0.096	0.078	0.061	0.075

Table 7a. F_T= 0.10, population numbers from cohort (X 10^{-3})

POPULATION NUMBERS

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	27790	45728	52968	69258	106997	176288	268988	75412	6009
7	23814	25133	41276	47546	62628	96570	158238	242972	68054
8	17727	21537	21890	36688	42968	56201	83437	141744	218921
9	16882	16025	17703	18030	32947	38404	43853	72925	126567
10	16700	15268	12933	15179	15761	29060	27728	36960	63725
11	20081	15092	12362	11240	13367	13467	21345	23561	31609
12	21276	17661	11915	10127	9758	11356	9943	18462	19863
13	24424	18297	14649	10189	8682	7905	8326	8026	15545
14	33455	19174	13129	12289	8277	7049	6338	6855	6664
15	66966	24470	14441	10812	10055	6517	5346	5059	5439
16	37368	51733	19123	10968	8763	7730	4792	4365	4027
17	74643	28232	39523	13867	8216	7175	6113	3909	3652
18	32978	60595	23075	27745	11478	6199	5740	4957	3189
19	32671	28088	51091	15134	21153	9430	4594	4672	4193
20	24820	28727	24404	34757	11889	16611	7722	3652	3928
21	19554	21365	24732	19214	25414	9341	13239	6364	3001
22	15174	17133	18665	20169	15994	18564	7957	11008	5351
23	11269	13363	14023	14910	15979	12302	15338	6557	9191
24	8856	9813	9408	11017	11630	12177	10142	12677	5473
25	7145	7553	7538	7762	8722	8591	9991	8481	10713
26	26	6305	4792	5674	4865	6862	6772	8039	7216
27	19	22	3910	3390	3600	3813	5568	5470	6808
28	23	15	18	2885	2241	2880	2944	4606	4722
29	21	19	12	14	2063	1736	2284	2336	3895
6+	533684	491348	453579	428859	463445	566228	736735	719069	637754
7+	505894	445620	400612	359602	356449	389940	467747	643656	631745
8+	482080	420487	359335	312056	293821	293370	309509	400685	563691
9+	464353	398950	337445	275368	250853	237169	226072	258941	344770
10+	447471	382925	319742	257338	217906	198764	182220	186016	218203
11+	430771	367657	306809	242159	202145	169704	154492	149056	154478
12+	410689	352565	294448	230919	188778	156237	133147	125495	122869
13+	389413	334905	282533	220792	179020	144881	123204	107033	103006
14+	364988	316608	267883	210604	170338	136976	114878	99007	87461

Table 7b. F_T=0.10, mid-year biomass from cohort (t).

POPULATION BIOMASS (MID-YEAR)

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	2776	4564	5272	6918	10678	17546	26855	7525	646
7	3217	3333	5529	6421	8429	12758	21277	32765	8859
8	2984	3462	3522	6157	7194	8810	13817	23720	36746
9	3421	3072	3495	3593	6595	6981	8586	14531	26299
10	3923	3400	2980	3521	3602	6176	6320	8451	15920
11	5390	3844	3205	2998	3528	3322	5682	6195	8540
12	6537	5332	3651	3107	2912	3231	2963	5614	6228
13	8005	5745	4957	3395	2892	2617	2792	2703	5028
14	11664	6778	4845	4521	2989	2500	2304	2485	2519
15	26265	9651	5618	4339	3934	2497	2153	2013	2100
16	15674	21815	7866	4582	3820	3314	2085	1923	1697
17	34766	13193	17176	6519	3695	3318	2846	1825	1705
18	16849	30807	10411	13438	5762	2962	2869	2524	1563
19	17996	15381	24889	7893	11030	5017	2410	2518	2360
20	14314	16568	13479	18532	6560	9229	4360	2059	2225
21	12034	13130	14699	11533	14329	5670	7943	3839	1635
22	9804	10682	11502	12379	9678	11627	4977	6930	3152
23	7619	8160	9021	9558	10130	8099	10111	4343	5431
24	6304	6641	6590	7565	7726	8507	7151	8984	3507
25	5481	4952	5354	5060	6328	6239	7327	6391	7049
26	21	4336	3504	3943	3735	5356	5275	6406	5127
27	15	18	3078	2534	2946	3067	4631	4644	5004
28	20	12	15	2324	1875	2437	2491	4020	3732
29	19	17	10	12	1790	1535	2039	2105	3117
6+	215097	194893	170669	150842	142158	142816	159263	164512	160191
7+	212321	190329	165397	143924	131480	125271	132408	156987	159545
8+	209103	186996	159868	137503	123052	112513	111131	124222	150686
9+	206119	183534	156346	131346	115858	103704	97314	100502	113939
10+	202698	180462	152851	127753	109263	96722	88728	85971	87640
11+	198775	177062	149870	124232	105660	90546	82408	77520	71720
12+	193385	173218	146665	121234	102133	87224	76726	71325	63180
13+	186848	167886	143014	118128	99220	83992	73763	65711	56952
14+	178843	162141	138057	114733	96329	81375	70971	63008	51924

Table 7c. F_T = 0.10, fishing mortalities from cohort.

FISHING MORTALITY

AGE	1973	1974	1975	1976	1977	1978	1979	1980	1981
6	0.000	0.002	0.008	0.001	0.003	0.008	0.002	0.003	0.001
7	0.000	0.038	0.018	0.001	0.008	0.046	0.010	0.004	0.003
8	0.001	0.096	0.094	0.008	0.012	0.148	0.035	0.013	0.007
9	0.000	0.114	0.054	0.034	0.026	0.226	0.071	0.035	0.015
10	0.001	0.111	0.040	0.027	0.057	0.209	0.063	0.056	0.027
11	0.028	0.136	0.099	0.041	0.063	0.203	0.045	0.071	0.043
12	0.051	0.087	0.057	0.054	0.111	0.210	0.114	0.072	0.064
13	0.142	0.232	0.076	0.108	0.108	0.121	0.094	0.086	0.089
14	0.213	0.184	0.094	0.101	0.139	0.177	0.125	0.131	0.100
15	0.158	0.147	0.175	0.110	0.163	0.208	0.103	0.128	0.100
16	0.180	0.169	0.221	0.189	0.100	0.135	0.104	0.078	0.100
17	0.108	0.102	0.254	0.089	0.182	0.123	0.109	0.104	0.100
18	0.061	0.071	0.322	0.171	0.097	0.200	0.106	0.068	0.100
19	0.029	0.041	0.285	0.141	0.142	0.100	0.130	0.074	0.100
20	0.050	0.050	0.139	0.213	0.141	0.127	0.093	0.096	0.100
21	0.032	0.035	0.104	0.083	0.214	0.060	0.085	0.073	0.100
22	0.027	0.100	0.125	0.133	0.162	0.091	0.094	0.080	0.100
23	0.038	0.251	0.141	0.148	0.172	0.093	0.091	0.081	0.100
24	0.059	0.164	0.092	0.134	0.203	0.098	0.079	0.068	0.100
25	0.025	0.355	0.184	0.367	0.140	0.138	0.117	0.062	0.100
26	0.084	0.378	0.246	0.355	0.144	0.109	0.113	0.066	0.100
27	0.121	0.102	0.204	0.314	0.123	0.159	0.090	0.047	0.100
28	0.095	0.153	0.126	0.235	0.155	0.132	0.131	0.068	0.100
29	0.105	0.117	0.201	0.161	0.159	0.120	0.100	0.080	0.100

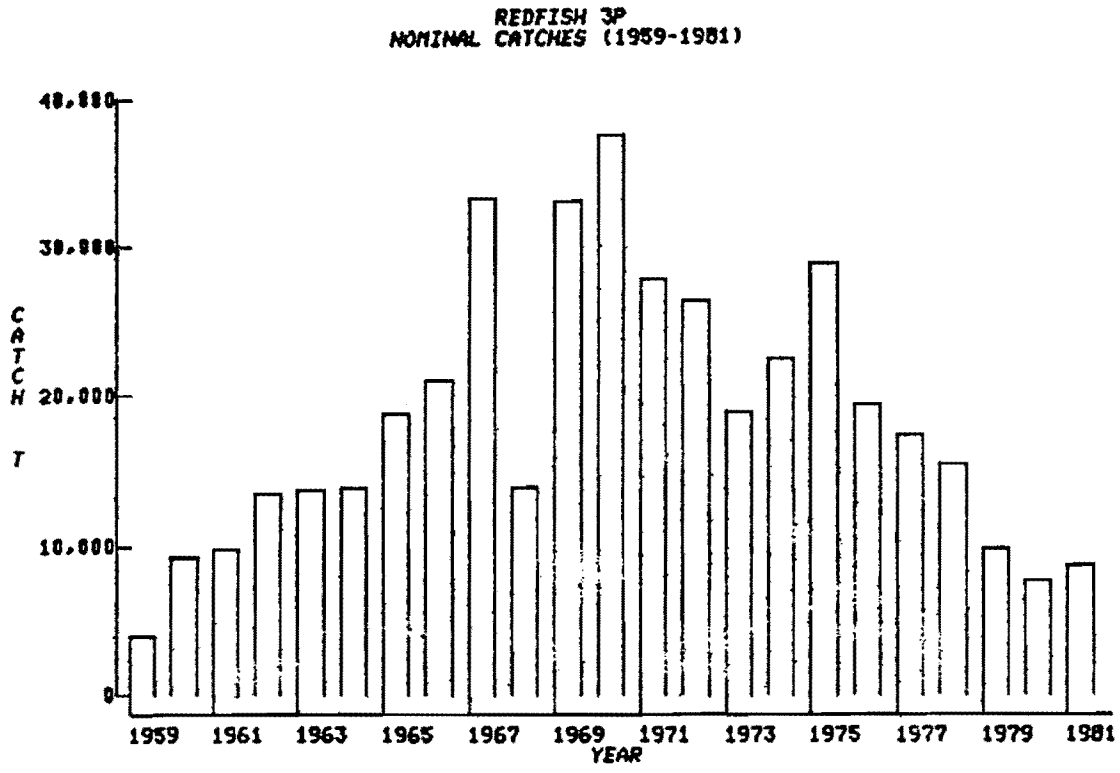
Table 8. Summary of various regressions of biomass (from cohort) vs. CPUE for 3P redfish.

	Biomass at beginning of year (1973-80)								
	6+			10+			14+		
F_T	Slope / intercept	r^2	O/E^a	Slope / intercept	r^2	O/E^a	Slope / intercept	r^2	O/E^a
0.025	-/+	.2123	1.24	+/+	.9214	1.07	+/+	.7938	0.77
0.05	+/+	.0220	1.16	+/-	.9044	0.99	+/-	.8246	0.70
0.075	+/+	.5819	1.09	+/-	.8950	0.91	+/-	.8351	0.65
0.10	+/+	.8563	1.03	+/-	.8897	0.85	+/-	.8404	0.60

Mid-year biomass

	1973-80				1974-80			
	10+				10+			
F_T	Slope / intercept	r^2	O/E^a		Slope / intercept	r^2	O/E^a	
0.025	+/+	.9330	1.09		+/+	.9515	1.10	
0.05	+/-	.9236	1.00		+/-	.9585	1.03	
0.075	+/-	.9158	0.93		+/-	.9520	0.97	
0.10	+/-	.9113	0.87		+/-	.9475	0.91	

[a] O 1981 biomass from cohort.
E 1981 biomass predicted from regression.



1981 *PROVISIONAL*

Fig. 1. Nominal catches of 3P redfish, 1959-81.

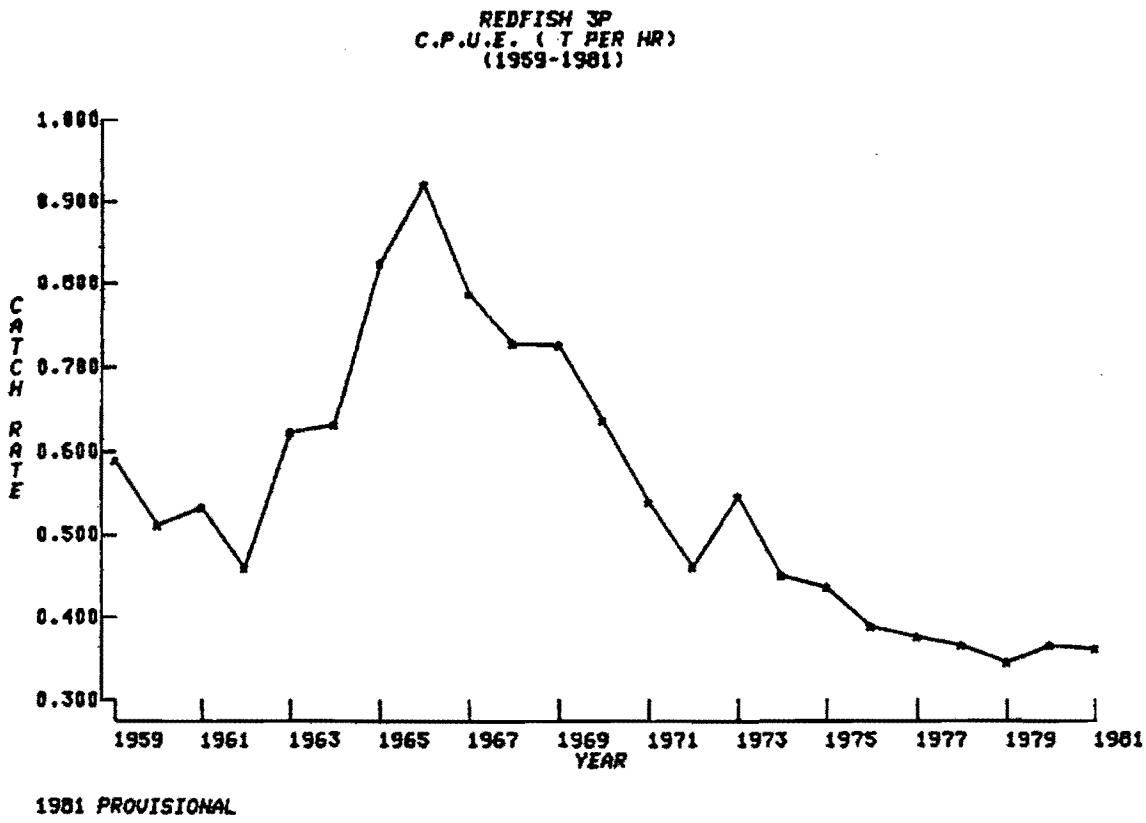


Fig. 2 Standardized CPUE 3P redfish, 1959-81.

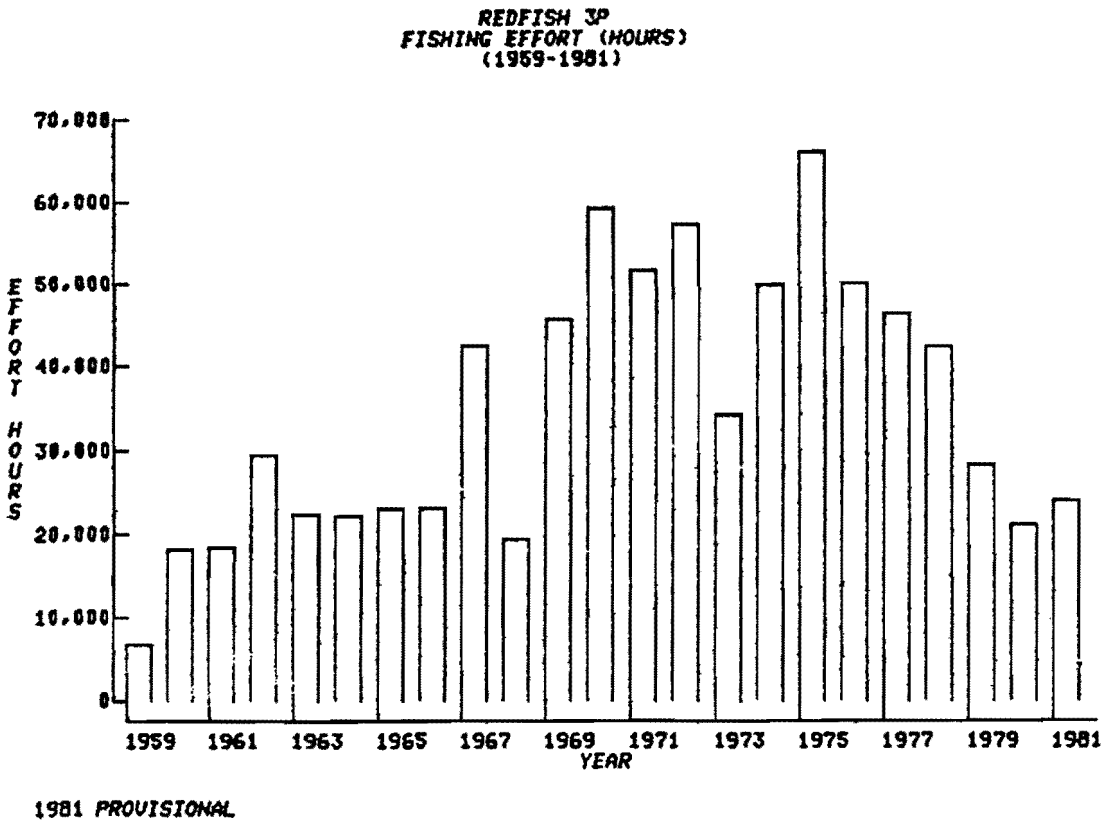


Fig. 3. Standardized effort, 3P redfish, 1959-81.

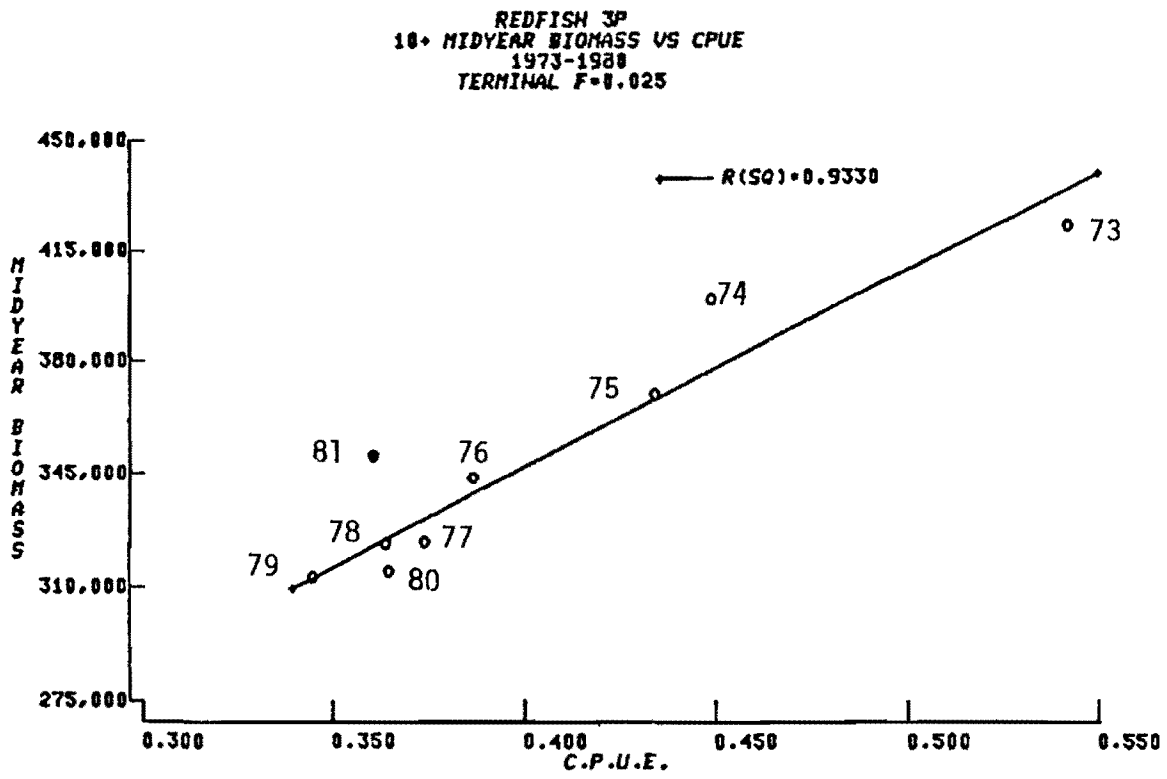


Fig. 4. F_T = 0.025, regression of 10+ mid-year biomass on CPUE, 1973-80.

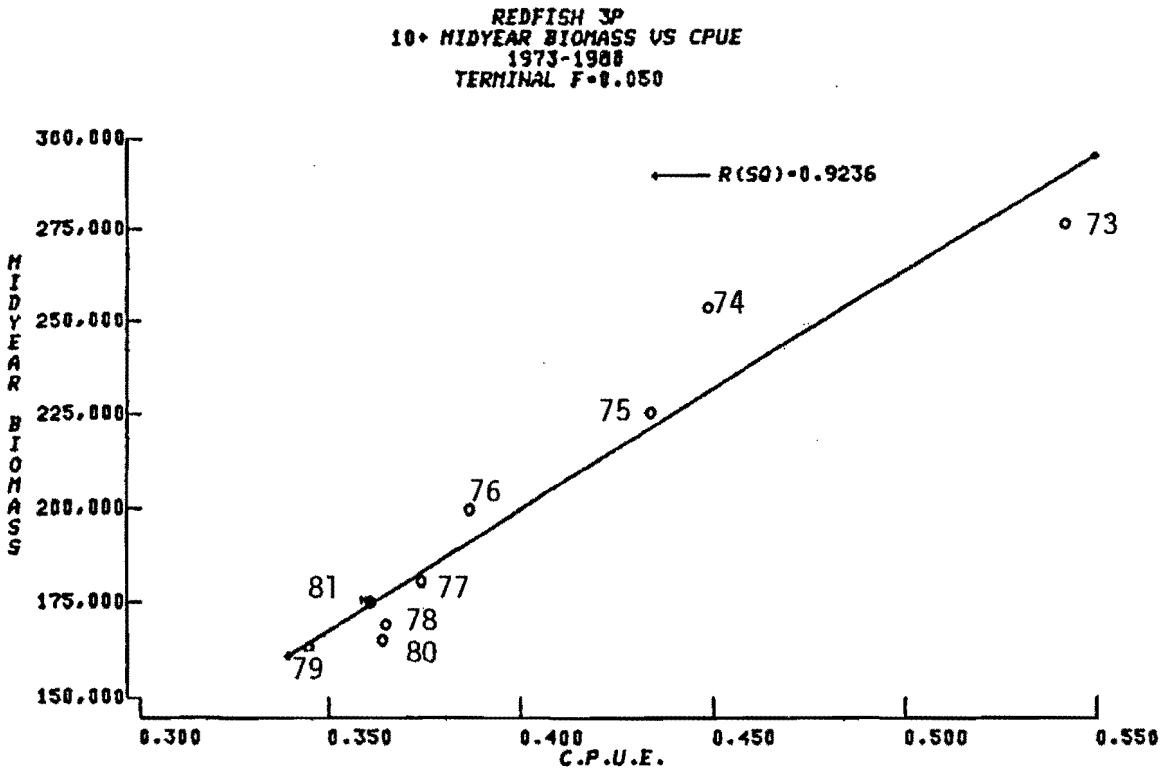


Fig. 5. $F_T = 0.05$, regression of 10+ mid-year biomass on CPUE, 1973-80.

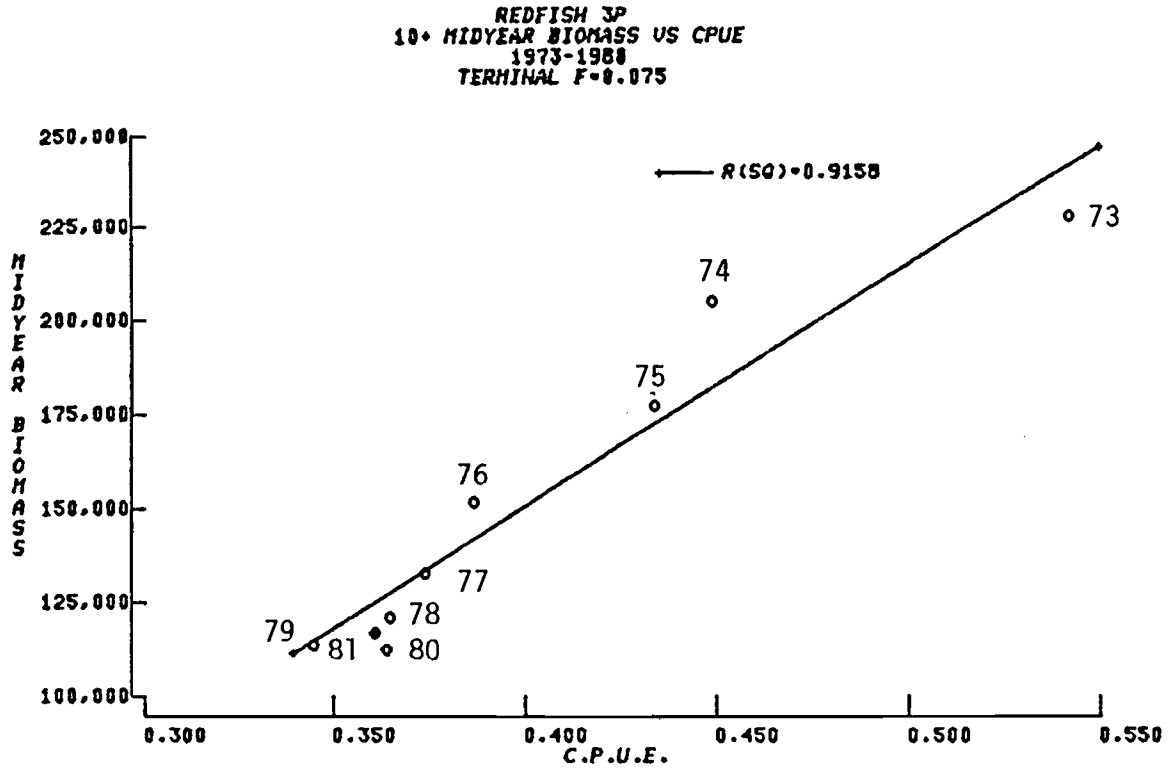


Fig. 6. F_T = 0.075, regression of 10+ mid-year biomass on CPUE, 1973-80.

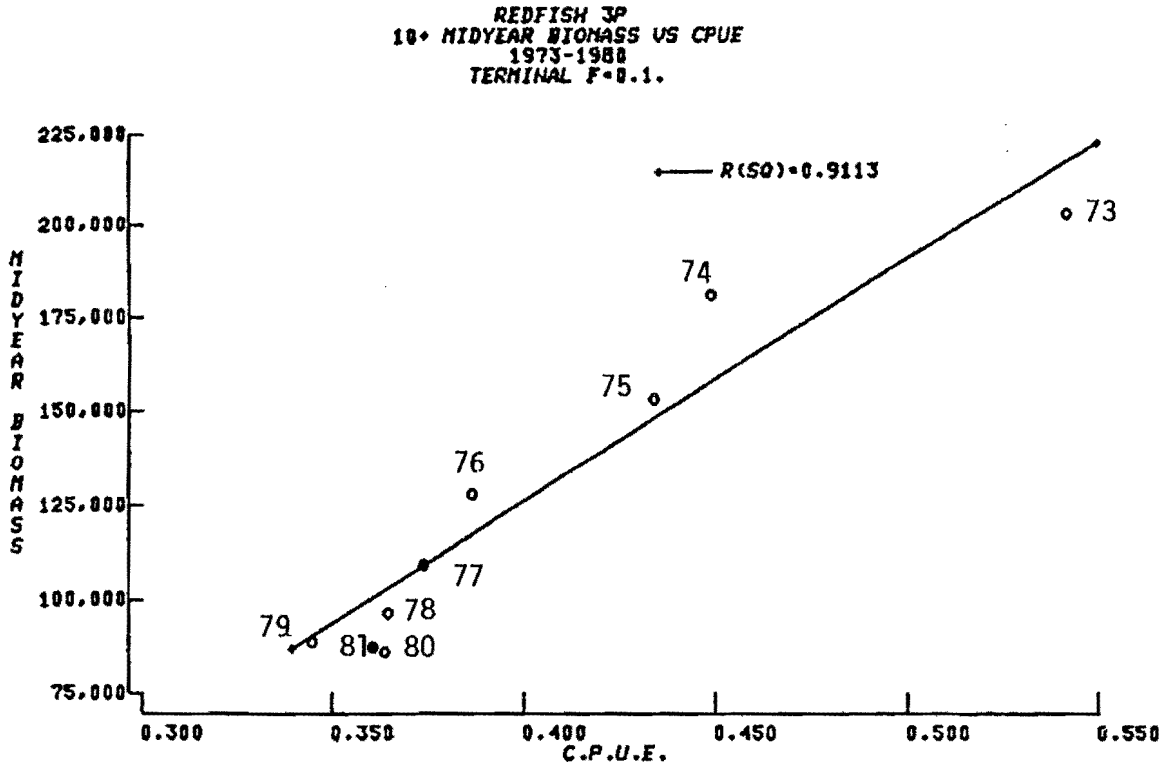


Fig. 7. F_T = 0.075, regression of 10+ mid-year biomass on CPUE, 1973-80.

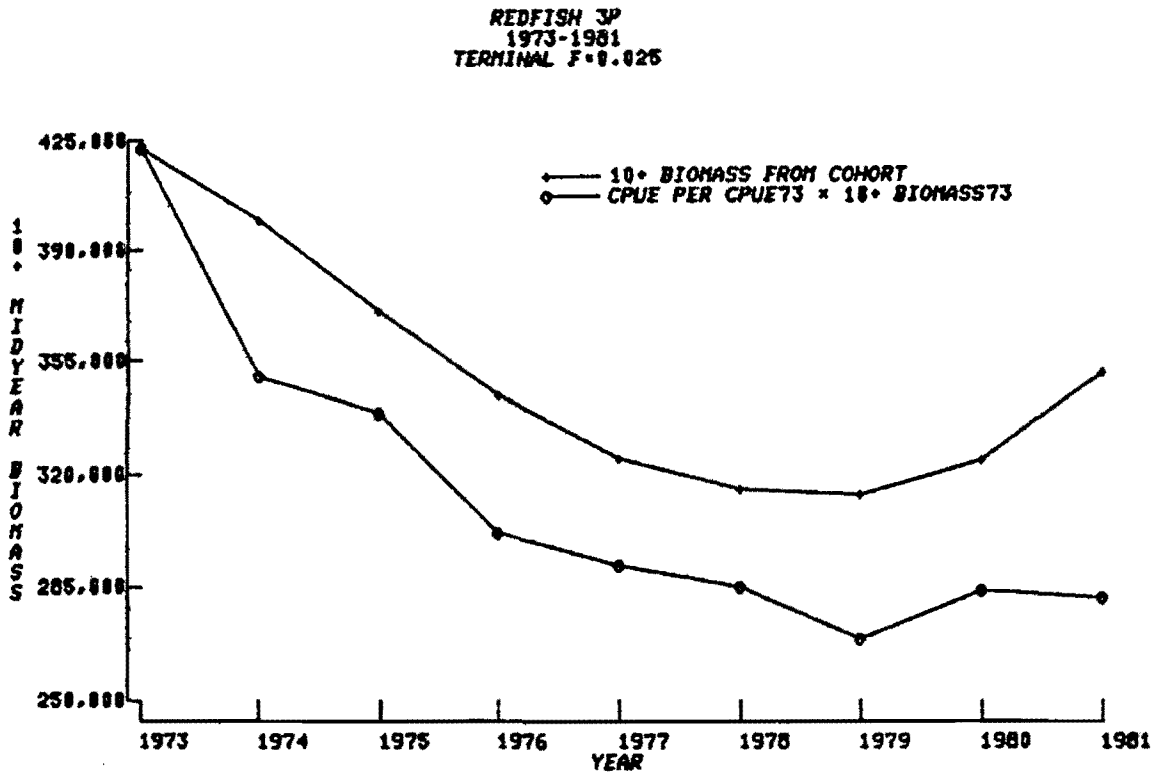


Fig. 8. CPUE standardized to 1973 CPUE X 10+ biomass 1973 and 10+ biomass from cohort, F_T = 0.025.

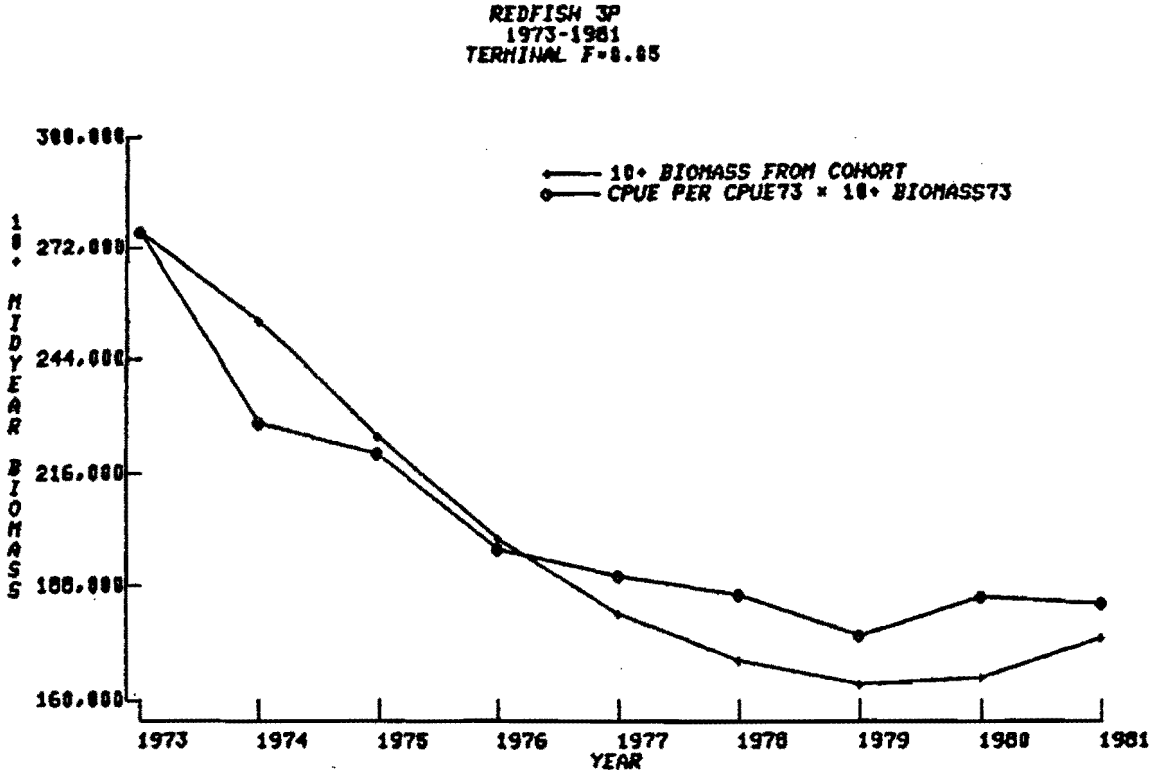


Fig. 9. CPUE standardized to 1973 CPUE X 10+ biomass 1973 and 10+ biomass from cohort, F_T = 0.50.

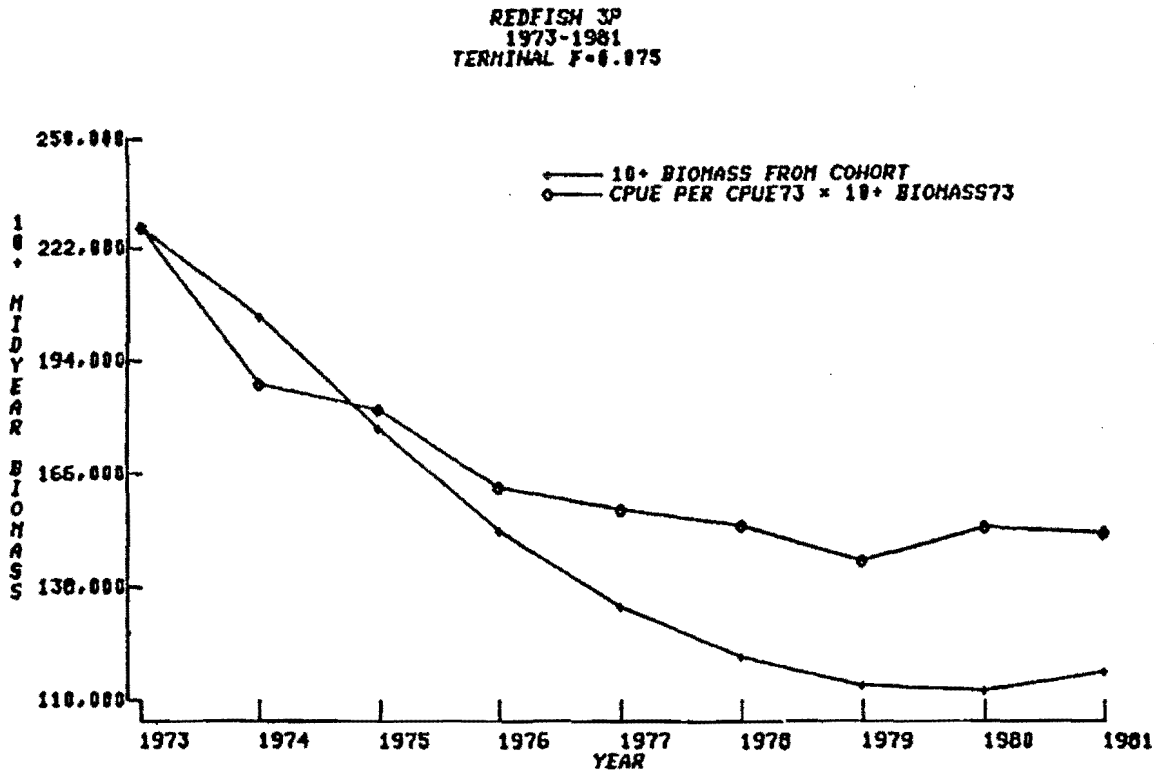


Fig. 10. CPUE standardized to 1973 CPUE X 10+ biomass 1973 and 10+ biomass from cohort, F_T = 0.075.

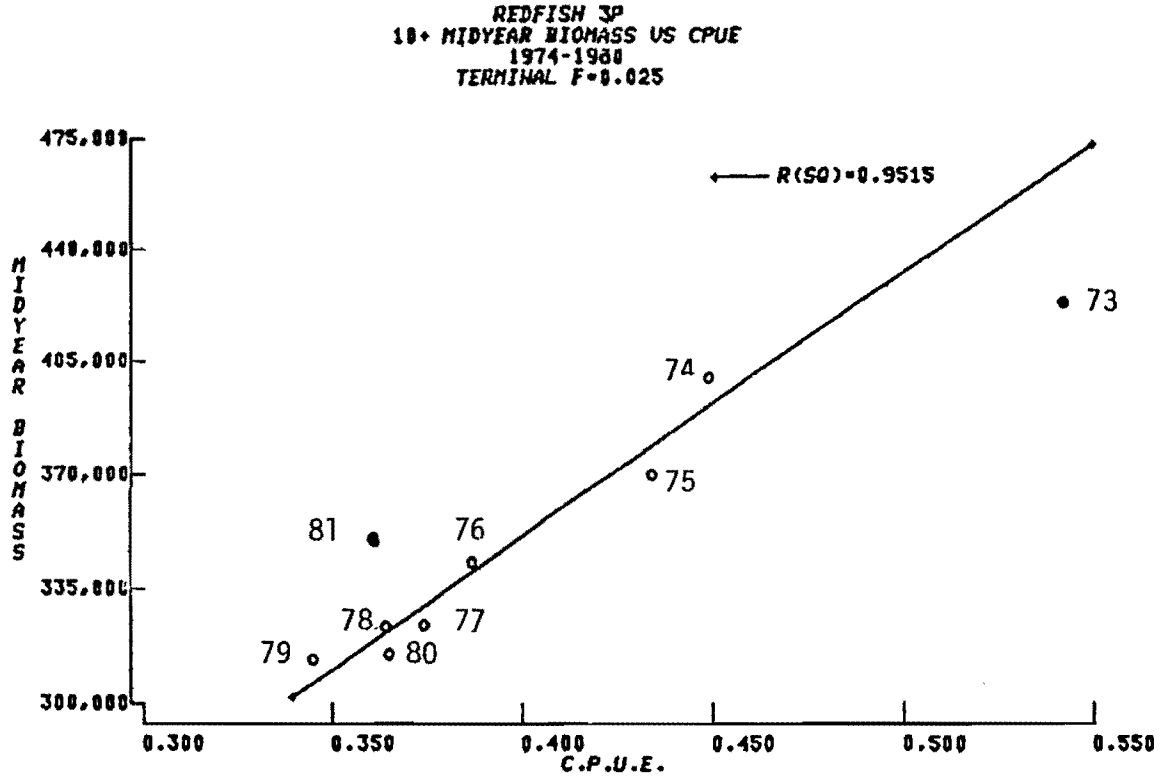


Fig. 11. F_T = 0.025, regression of 10+ biomass from cohort on CPUE, 1974-80.

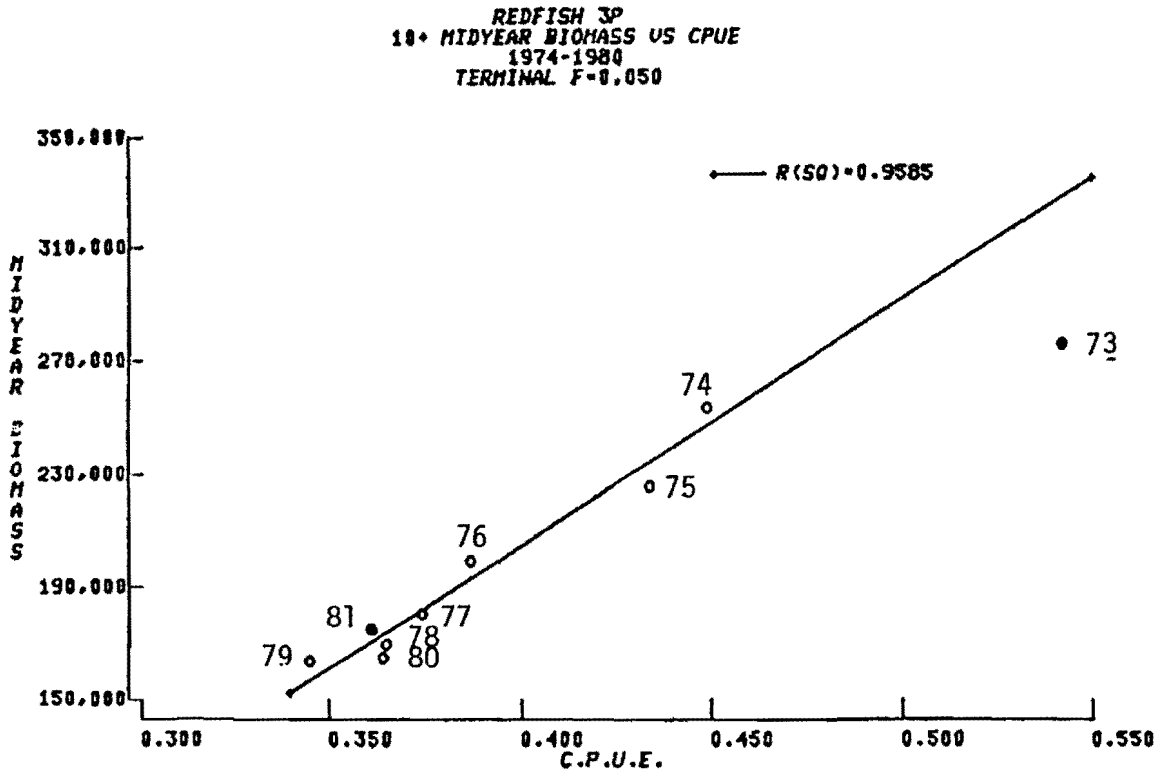


Fig. 12. F_T = 0.05, regression of 10+ biomass from cohort on CPUE, 1974-80.

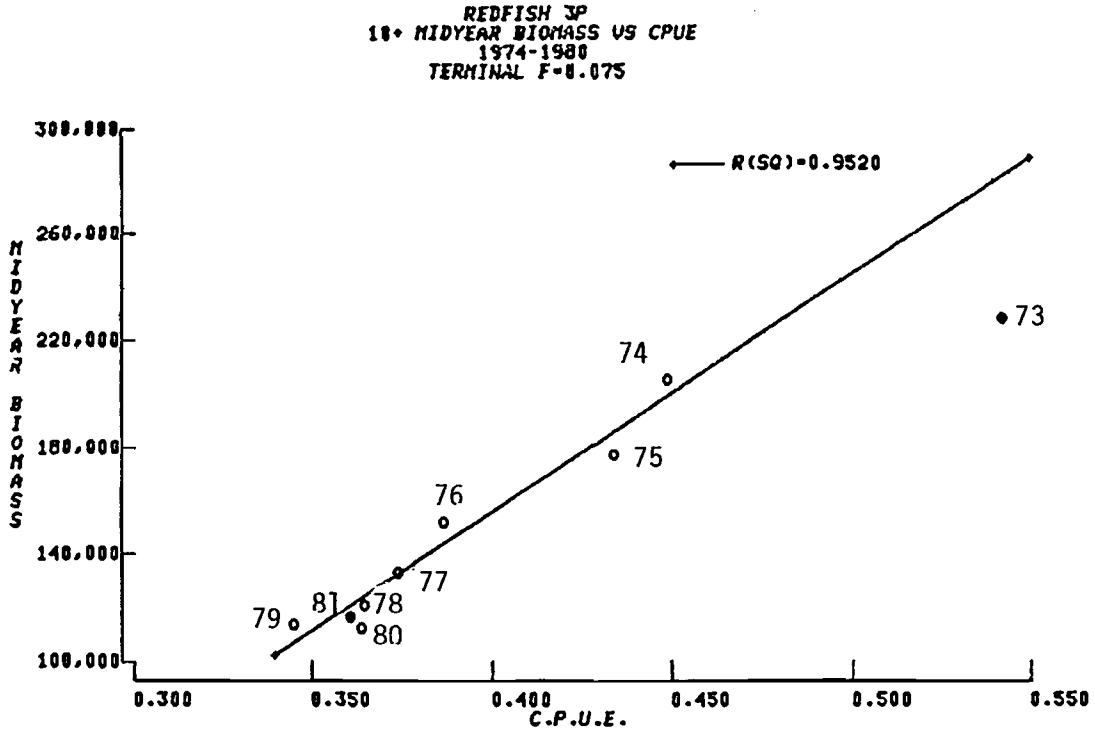


Fig. 13. F_T = 0.075, regression of 10+ biomass from cohort on CPUE, 1974-80.

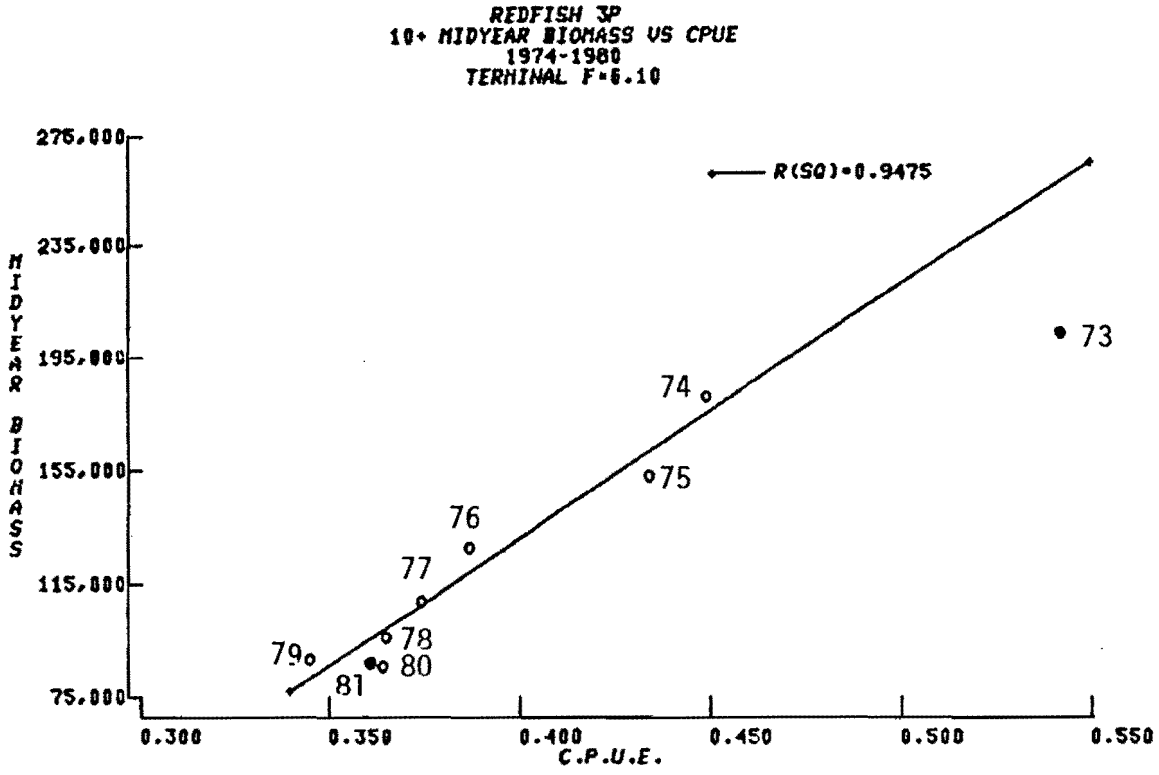


Fig. 14. F_T = 0.10, regression of 10+ biomass from cohort on CPUE, 1974-80.

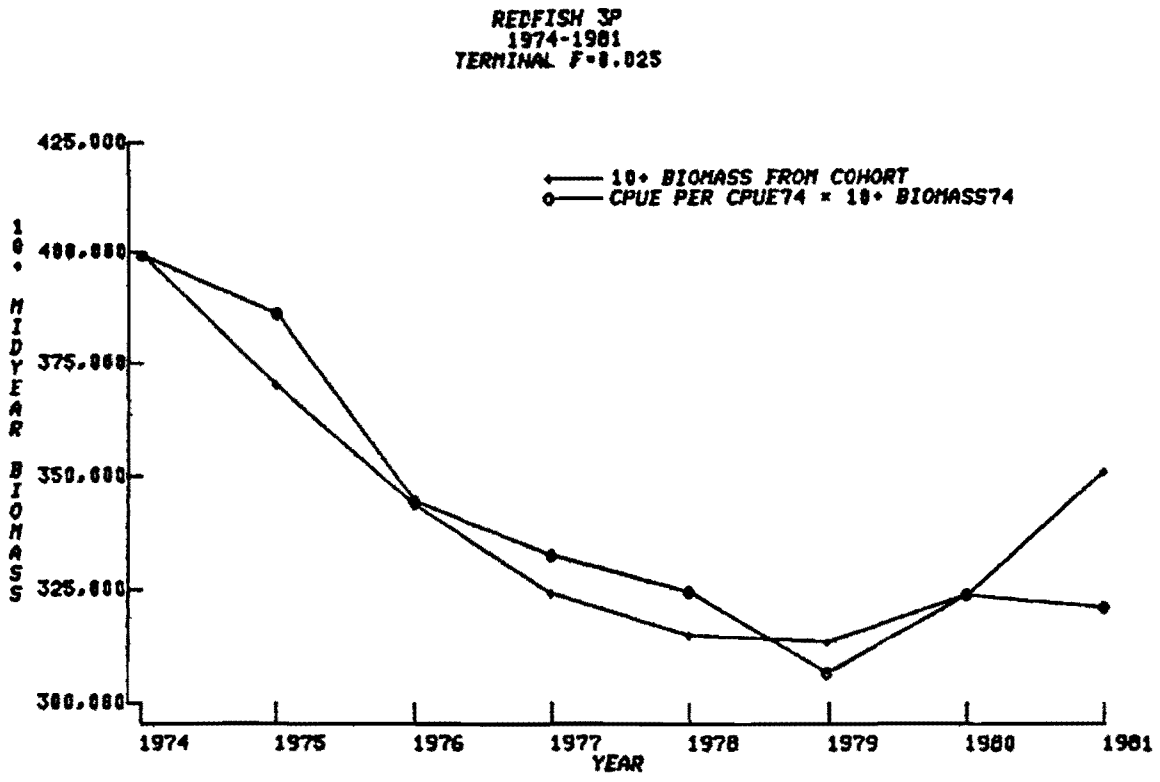


Fig. 15. CPUE standardized to 1974 CPUE X 10+ biomass 1974 and 10+ biomass from cohort, F_T = 0.025.

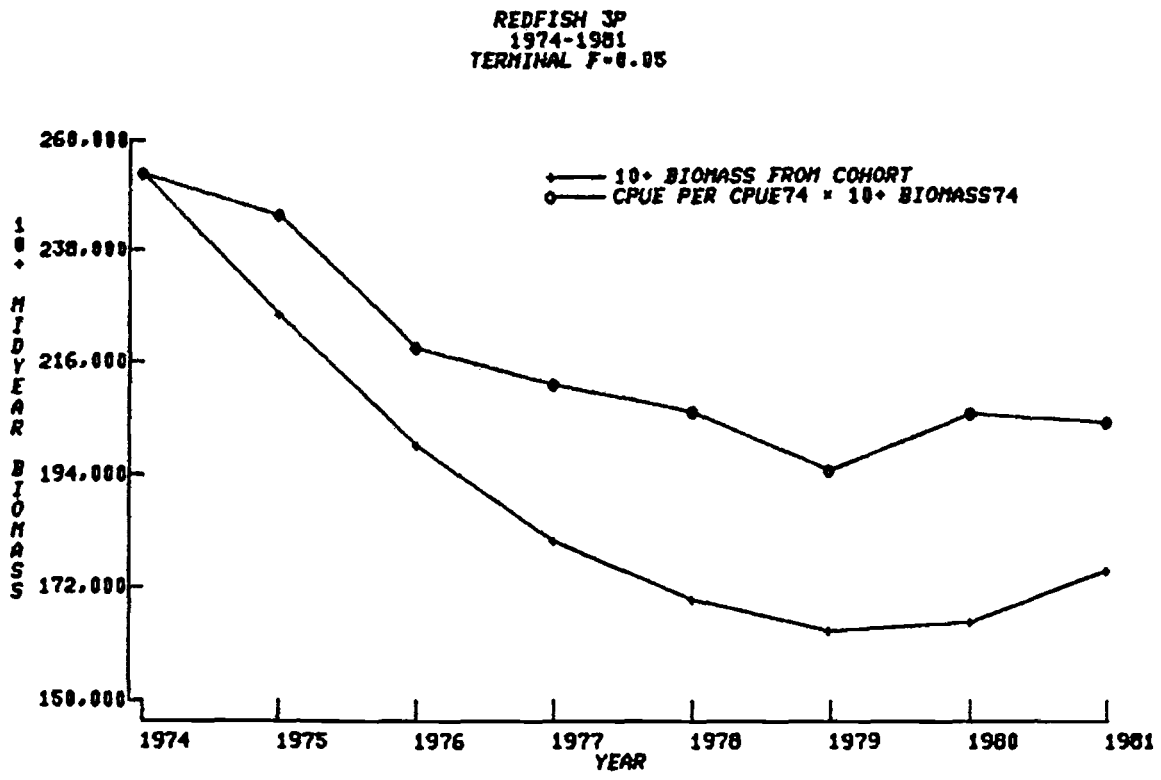


Fig. 16. CPUE standardized to 1974 CPUE X 10+ biomass 1974 and 10+ biomass from cohort, F_T = 0.05.

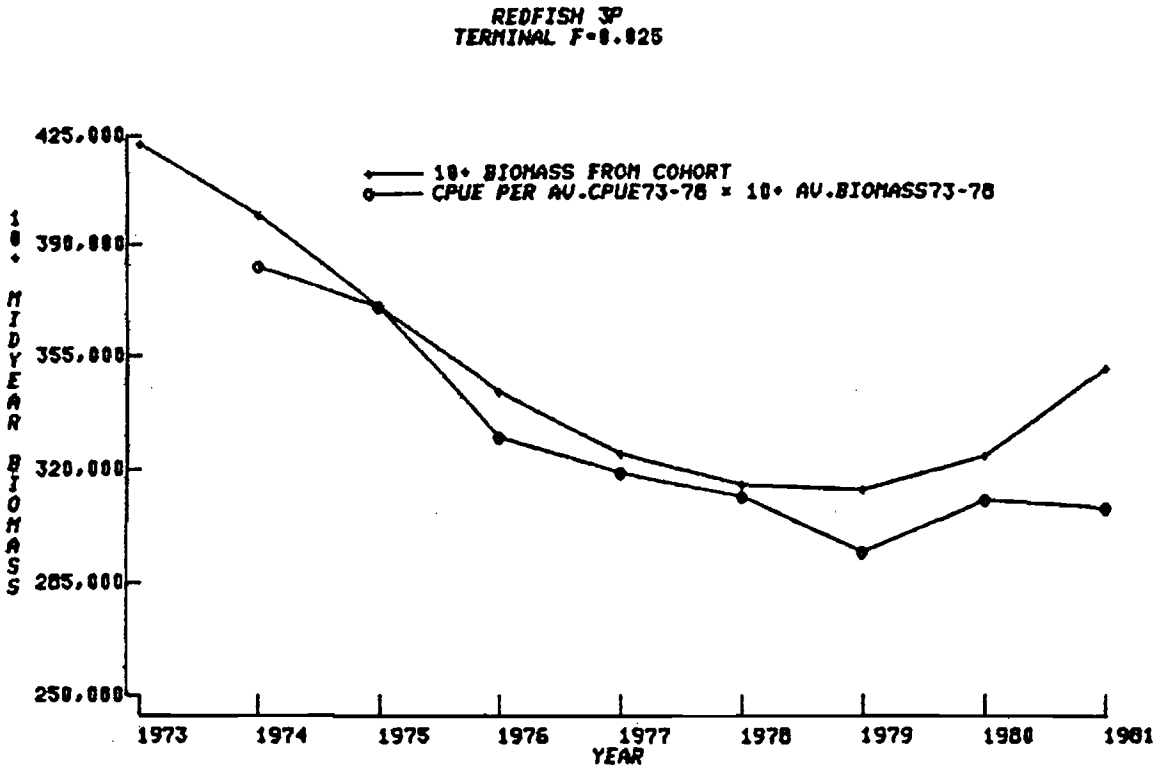


Fig. 17. CPUE standardized to average CPUE 1973-78 X average 10+ biomass 1973-78 and 10+ biomass from cohort, F_T = 0.025.

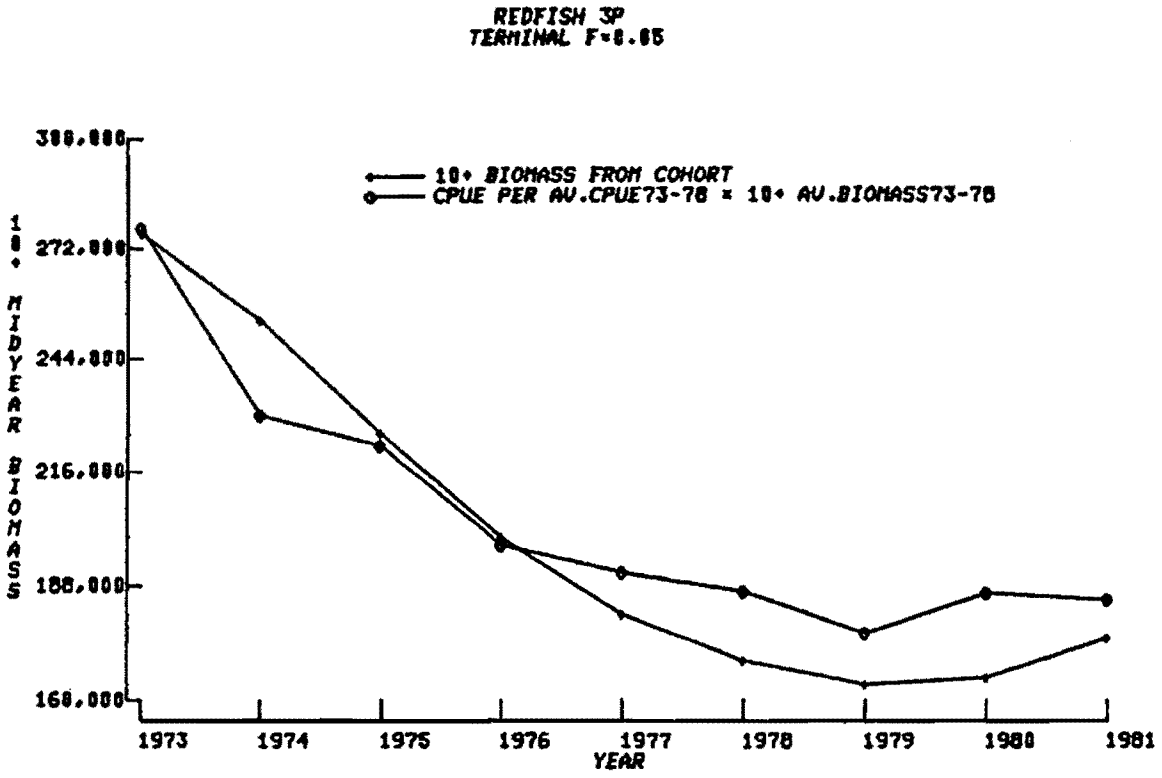


Fig. 18. CPUE standardized to average CPUE 1973-78 X average 10+ biomass 1973-78 and 10+ biomass from cohort, F_T = 0.05.

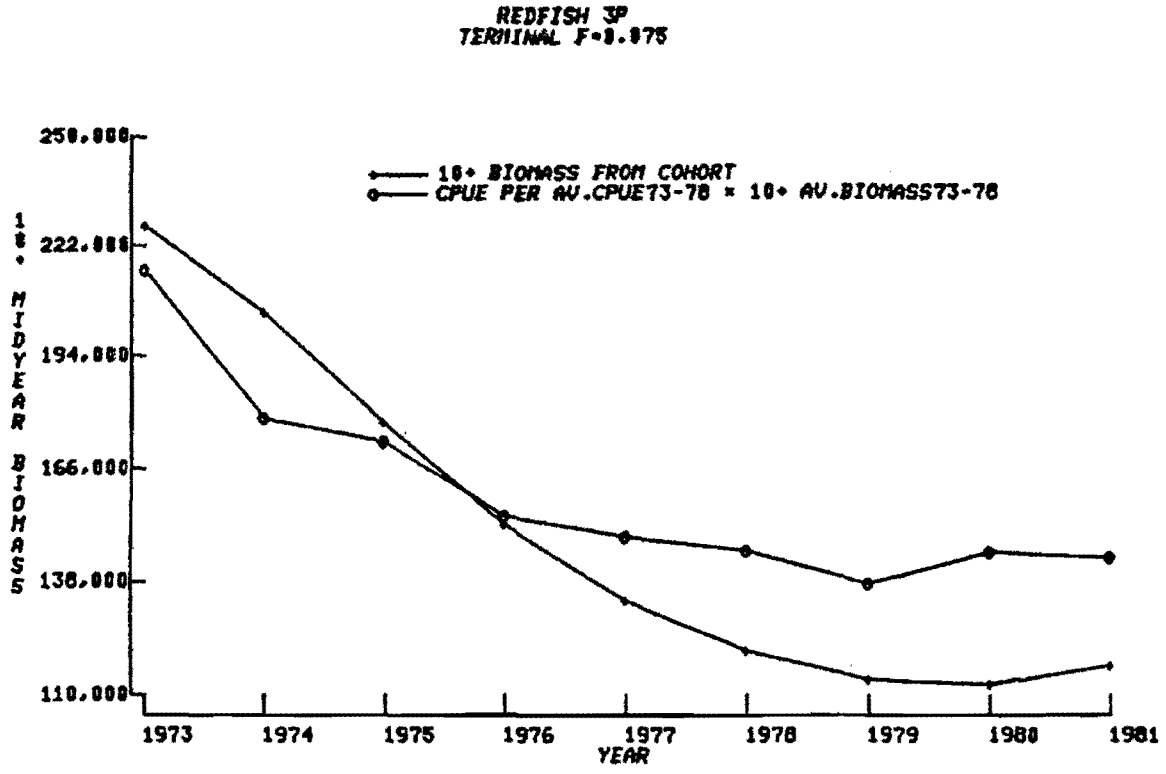


Fig. 19. CPUE standardized to average CPUE 1973-78 X average 10+ biomass 1973-78 and 10+ biomass from cohort, F_T = 0.075.

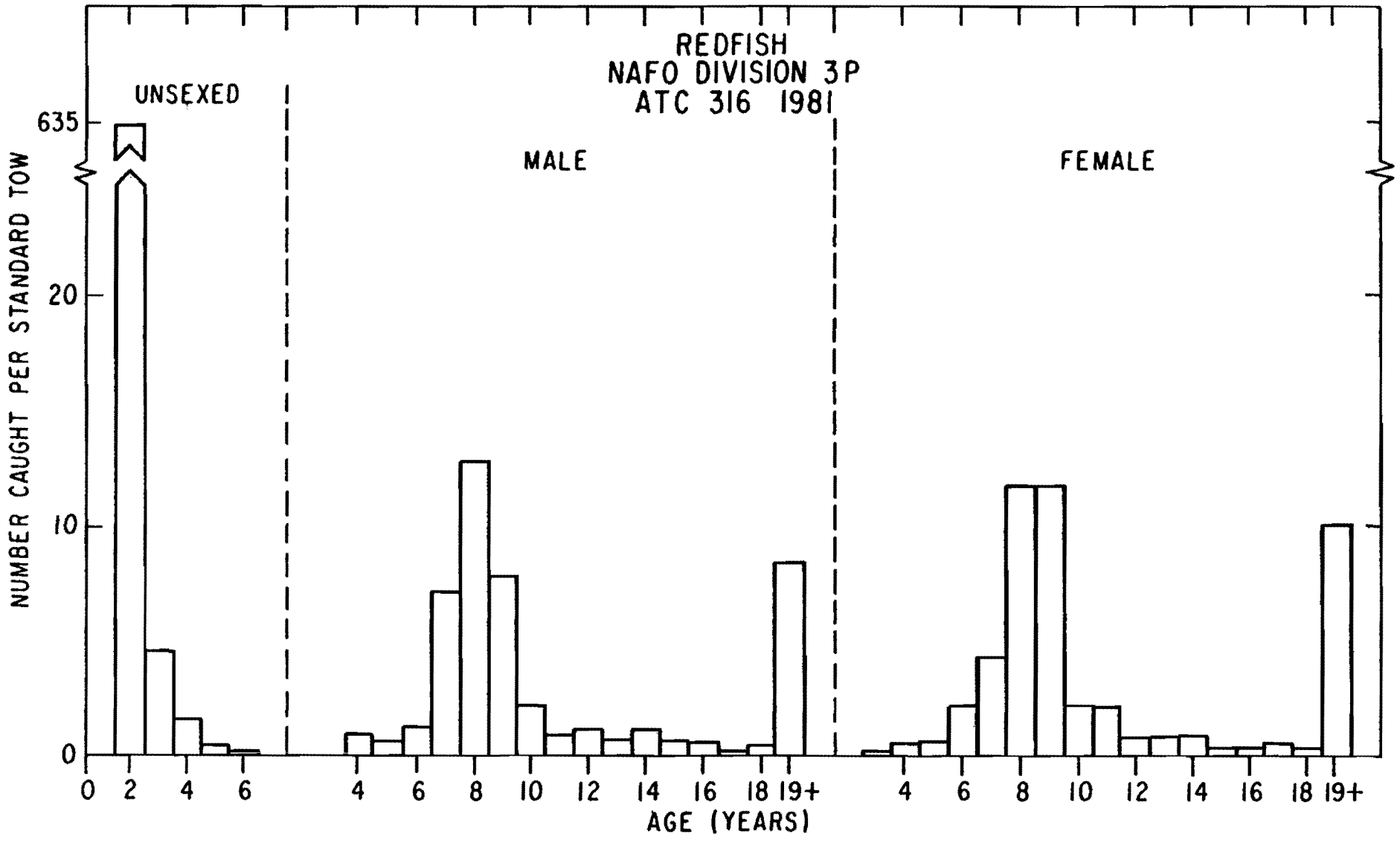


Fig. 20. No. redfish caught at age per standard tow during research survey in 3P, 1981.

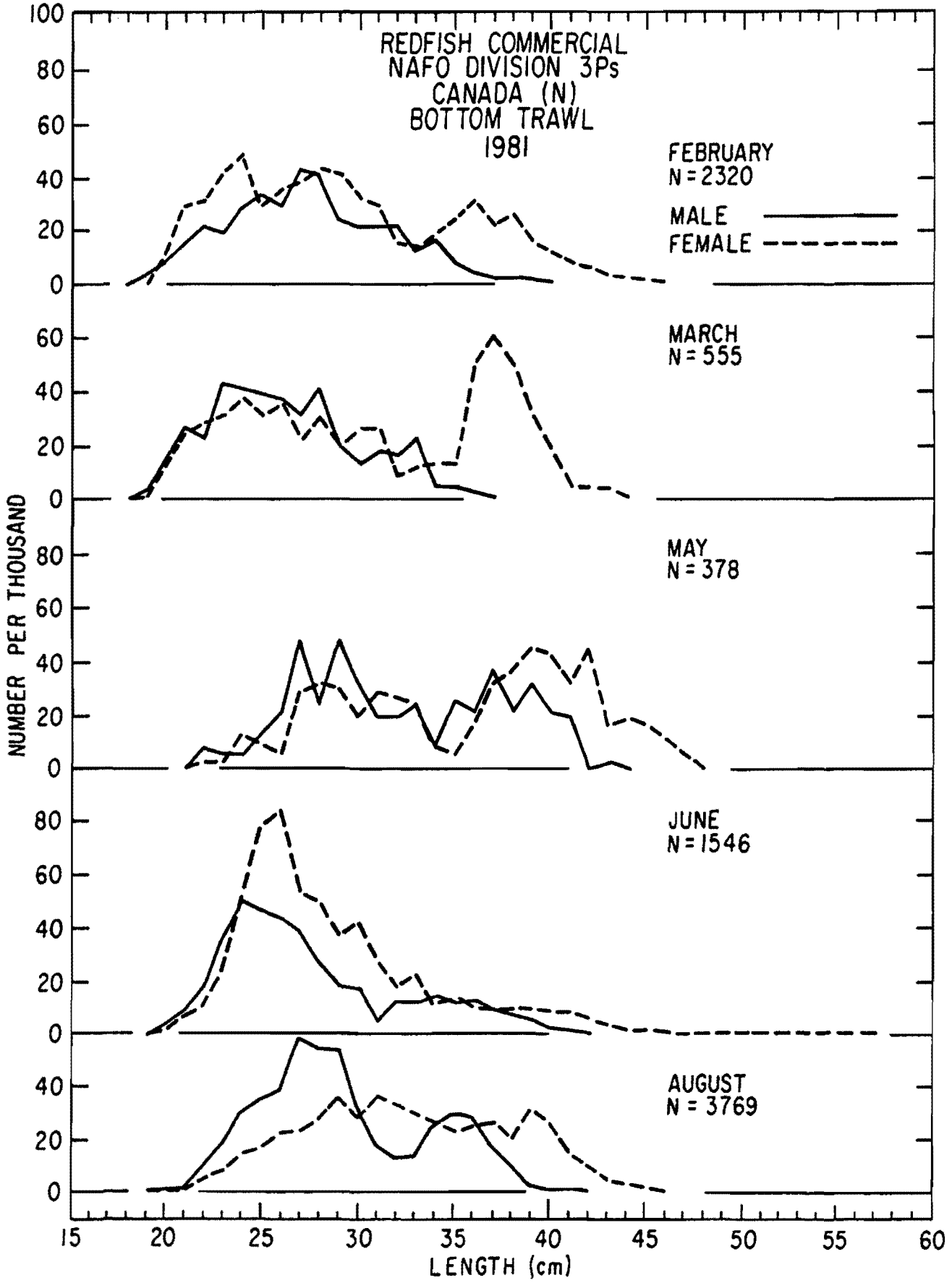


Fig. 21. Canada (N) commercial length frequencies of redfish in 3Ps, 1981.

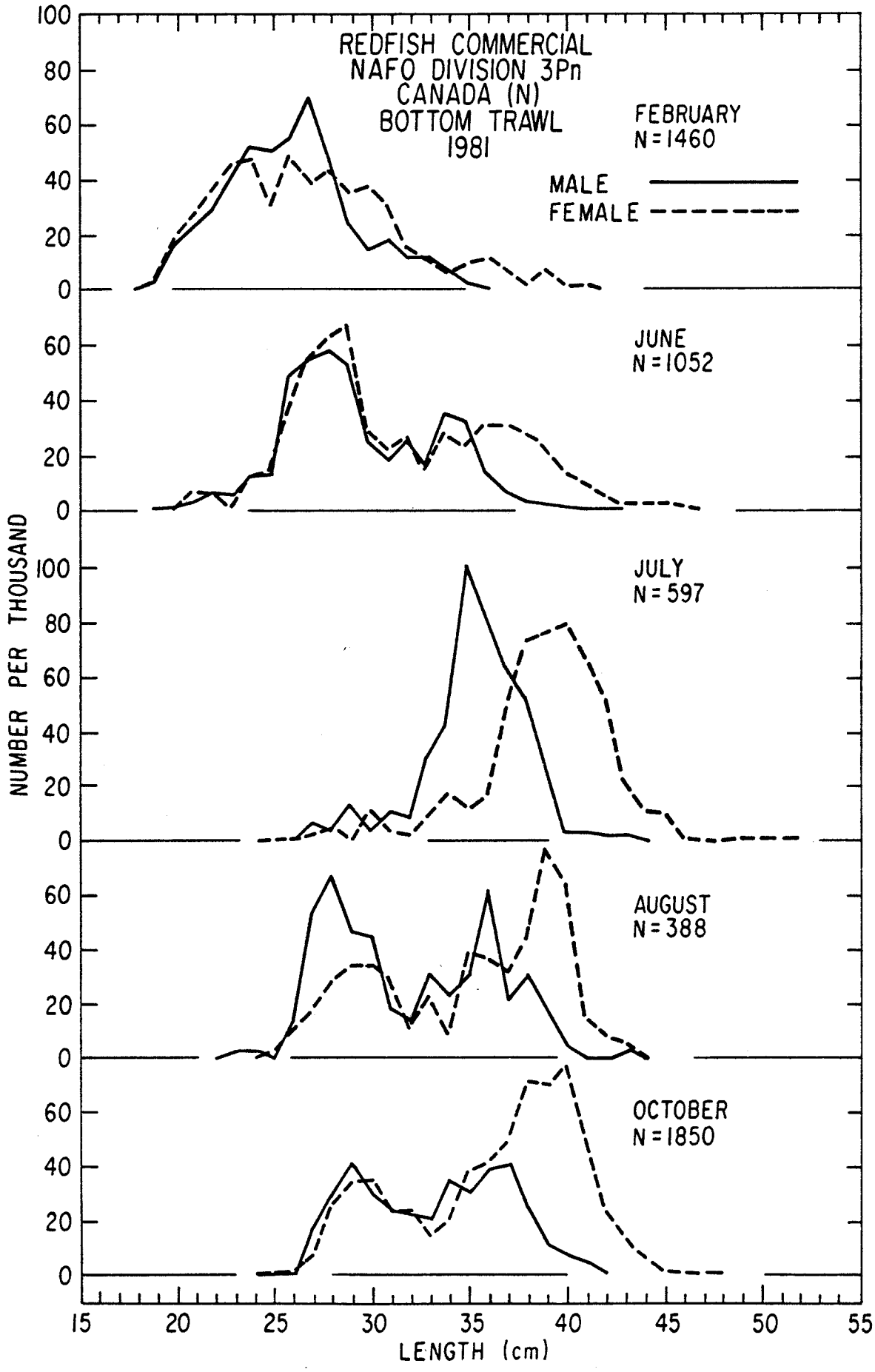


Fig. 22. Canada (N) commercial length frequencies from 3Pn, 1981.

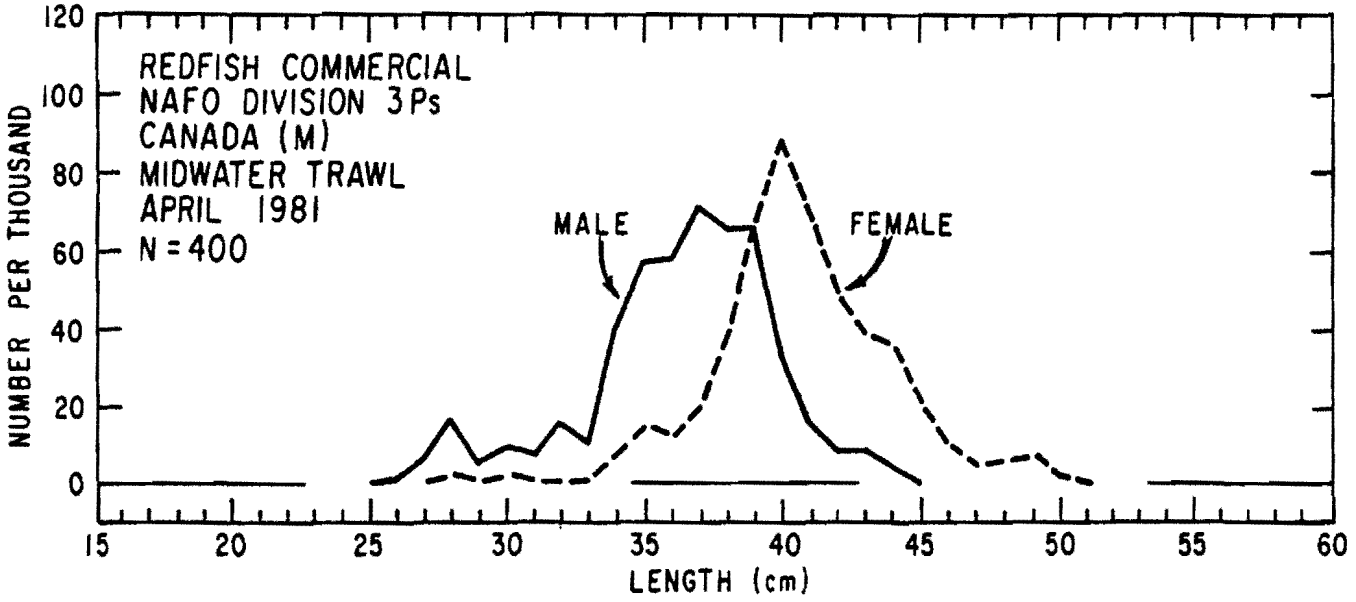


Fig. 23. Canada (Maritimes) commercial length frequency from 3Ps, 1981.