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The Witch fishery on the southern Grand Bank (Divisions 3NO)

by

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The landings reported from this fishery have been in the order of 3,000-9,000 t annually since 1972, however, the catches have been on a decreasing trend since 1974 from 8,000 t to a little over 3,000 t in 1979 (Table 1). Landings prior to 1972 were reported as unspecified flounders, consequently, the witch landings prior to that time should be treated with caution since they are probably overestimated. This fishery is prosecuted almost entirely by Canada and the USSR usually in winter-time when these fish form prespawning concentrations on the southwest slope of the Grand Bank.

In 1974 a precautionary TAC of 10,000 t was placed upon this stock until 1979 when it was reduced to 7,000 t as a result of an analytical assessment (Bowering, 1978). At the 1979 assessments meeting, a cohort analysis and general production assessment (Bowering, 1979) both indicated that the stock could probably only sustain fishing pressure up to 3,000-4,000 t annually. However, due to anomalies in the fishing pattern and uncertainties connected with real time fishing mortalities the subcommittee felt it could not advise any change in the TAC of 7,000 t. This TAC was therefore in effect for 1980.

Commercial sampling data: In previous years, commercial samples were secured from Canadian otter trawlers fishing this stock and this data was applied to the whole fishery. With the much reduced landings by the Canadian boats, obtaining samples over the past couple of years has been difficult. As a result, during 1979, it was impossible to gather any samples from the commercial fishery. The only available commercial catch-at-age data are that presented in last years assessment (Bowering, 1979).

Catch and effort:

Catch per unit effort data from Canada (Newfoundland) boats were available for the past 16 years where catch and effort was reported as main species as well as by-catch. Since this fishery is very small and concentrated at a particular time of year, for the years 1964-79, effort was considered to be directed at witch where witch was reported as main species. Only stern trawler data were used since very little other data were available. Using this as a standard, total effort figures were calculated according to total landings (Table 2).

A regression of CPUE on effort was computed using a 4-year running average of effort (Table 2, Fig. 1) where a good correlation was found to exist in this case ($r=0.77$). The values derived from the regression was used to generate a general production curve (Fig. 2). The MSY value from this curve is approximately 7,000 t at an effort of 14,000 hours at equilibrium. The 2/3 MSY level is between 4,000-5,000 t. It is obvious from the curve, that the yield has decreased steadily since 1974 within a fairly narrow range of calculated effort. Considering the position of the yield-effort points (Fig. 2) over the past few years, it is unlikely that the catch would exceed 3,000 t if the effort remains relatively stable. In fact the 1979 yield-effort point falls along the origin-1978 line as expected from the previous assessment.

Catch curves from commercial data

As previously mentioned, catch-at-age data were not available for 1979. However, the numbers caught-at-age for 1974-78 were available from the previous assessment. The data from the 5 years were combined for males and females separately (Table 3) and catch curves were constructed for ages 13+ for both sexes (Fig. 3 and 4). The results of the regression are presented in Table 3). Placing these values on the appropriate

yield per recruit curves (Fig. 5, from Bowering, 1978) indicate that the average fishing mortality over approximately the past 10 years has been around the $F_{0.1}$ level when considering males and females together. This would be in the order of 6,000 t. Considering, the CPUE and yield-effort figures, however, it is likely that this average is not a good reflection of recent years where fishing mortality has probably been higher.

Biomass Surveys

Since 1971, stratified-random biomass surveys have been conducted on the Grand Bank by the Newfoundland based research vessel A.T. Cameron. For various reasons such as malfunctions, inclement weather or other priorities, it was not always possible to fish in all strata. For 1971-79, the average numbers and weights per set for each survey in Division 3N are presented in Table 4. The total trawlable numbers and biomass are also shown for each year. These values, however, only represent the strata fished.

The surveys for 1973-80 were more complete for Division 3Ø and the results of these surveys are presented in Tables 5 and 6. The numbers in brackets represent the numbers of sets in each stratum from which the estimates are derived. Although the surveys in most cases were incomplete, it was obvious that the stock is essentially located in Division 3Ø as published in Bowering (1976).

To allow for comparison from year to year a total of 10 strata in Division 3Ø (since this was the main stock area) were selected such that all were fished each year from 1975-80. The trawlable biomass and numbers are presented in Table 7. Comparing the estimates of biomass from these strata to the total survey indicates that these are almost representative of the whole survey for each year. With the exception of the very low value in 1979, estimates ranged between 2300-4600 t with a general average of about 3,000 t.

Mortality estimates from biomass surveys

Using the same 10 strata in Div. 3Ø as in the previous section, trawlable populations numbers at age were calculated for the 1977 (Table 8), the 1978 (Table 9) and the 1979 (Table 10) surveys for males and females separately. The numbers at age were totalled for the 10 strata in each of the three years and presented in Table 11. There were essentially no fish caught below 7 years old. The 1977 and the 1978 survey were relatiely similar in age distribution, however, there were proportionately fewer older fish in the 1978 survey. Although the coverage was good in the 1979 survey the age composition was made up almost entirely of 4 age groups with none of the older groups present that were found in the 1977 and 1978 surveys. It appears that the problem may be one of geographical distribution since the last age group present appeared in high numbers.

Attempts were made to calculate Palaheimo Z's between 1977 and 1978 for males and females. For values around the fully-recruited age groups according to the commercial catches the mortality values were considered extremely high probably not realistic for either sex. Since the catch numbers at age for the 1979 survey was anomalous, these figures were not included in any of the calculations.

Catch curves were computed for the 1977 and 1978 surveys combined. For the males the Z value for 11-15 years was 0.89, however, for the commercial ages of 13+ the Z-value was 1.29 (Fig. 6). For the females, three catch curves were calculated. For ages 11-17 the Z-value was 0.60, for ages 11-16 the Z value was 0.36 (Table 11). For ages 13-16 which appeared most realistic according to the commercial age composition the Z-value was 0.42 (Fig. 7). The values for the males were high in comparison to that computed from the commercial statistics, however, the comparable value for the females is very similar. The computed values for both commercial and research catch curves are placed on the yield per recruit curves in Fig. 5.

Summary

The catch-effort data gave essentially the same results as presented in the previous assessment (Bowering, 1979). It did, however, show that the expected catch and effort figures for 1979 were very close to correct. The catch level for 1981 can be expected to be somewhat lower if the effort remains stable.

Biomass surveys tend to indicate low levels of abundance for this stock and the estimates of trawlable biomass are probably close to the average catches over recent years. It was almost impossible to obtain real time estimates of mortality from the data, however, average levels of mortality appear to indicate fishing mortality in the general vicinity of $F_{0.1}$ for the females from both commercial and research catches. The males appear close to $F_{0.1}$ from the commercial data, however, the F levels are quite high as

derived from the research catches.

While the precision of the data is not at a level one would prefer, most indications generally suggest a fishing level of 3,000-4,000 t.

Table 1. Nominal catches of witch in ICNAF Divisions 3N and 3Ø for 1967-78 ('000 metric tons).

Year	Canada	France	USSR	UK	Poland	GDR	Others	Total
1967	2,863		8,565	26	29	20		11,503
1968	1,503	18	9,078					10,599
1969	479	6	4,215					4,700
1970	723	1	6,039					6,763
1971	178	10	14,774		3			14,965
1972	3,419	17	5,738	3				9,177
1973	4,943	20	1,714	5	9			6,691
1974	2,807	1	5,235	2				8,045
1975	1,137		5,019				12	6,168
1976	3,044		2,991					6,035
1977	3,001		2,805					5,806
1978	1,178		2,276					3,454
1979	1,177		1,868				29	3,074

Table 2. Catch/effort witch 3NO.

Year	C/f(t)	Total Catch 3NO (MT)	Total effort (Hrs)	Effort 4 yr. Ave.
1964	0.426	1066	2502	
1965	0.619	1328	2145	
1966	0.642	7522	11717	
1967	0.671	11503	17143	8374
1968	0.592	10599	17904	12224
1969	0.459	4700	10240	14248
1970	0.556	6763	12164	14360
1971	0.316	14965	21501	15452
1972	0.715	9177	12835	14185
1973	0.502	6691	13329	14957
1974	0.337	8045	23872	17884
1975	0.252	6156	24429	18616
1976	0.271	6035	22269	20975
1977	0.365	5806	15907	21619
1978	0.249	3454	13871	19119
1979	0.186	3051	16403	17112

Regression of CPUE vs. Effort

r^2=0.59 (r=0.77)
Slope = -0.03652
Intercept = 1.00836

Table 3. Commercial witch 3NO.

Age	Nos. Caught 000's 1974-78	$Log_e N$	Nos. Caught 000's 1974-78	$Log_e N$
8	513	6.240	371	5.916
9	1282	7.156	574	6.353
10	2165	7.680	1919	7.560
11	3512	8.164	2572	7.852
12	4692	8.454	4724	8.460
13	4884	8.494	5181	8.553
14	2978	7.999	3907	8.271
15	1673	7.422	3162	8.059
16	665	6.500	2581	7.856
17	331	8.802	1765	7.476
18			820	6.709
19			266	5.583

	Reg. of $Log_e N_{13+}$ on age	
r^2	0.99	0.88
Slope	-0.70	-0.45
Intercept	17.74	14.71
Z	0.70	0.45
M	0.20	0.15
F	0.50	0.30

Table 4 A.T. Cameron 3N Biomass Survey

Average Number per set

Stratum	ATC 187 1971	ATC 199 1972	ATC 208-209 1973	ATC 222 1974	ATC 233 1975	ATC 245 1976	ATC 263 1977	ATC 277 1978	ATC 289 1979
357			3.50(2)				14.00(2)		14.33(3)
358		4.00(4)	3.00(3)				10.50(2)		2.00(2)
359		15.33(3)	28.33(3)			42.33(3)	3.00(2)		3.25(4)
360		0.25(4)			0.0(4)	1.25(4)	0.25(4)	1.75(4)	3.22(9)
361	0.0(2)	0.0(3)	0.0(4)	0.0(4)	1.49(4)	0.0(5)	0.33(3)	0.0(4)	0.13(8)
362	1.50(2)	0.0(4)	0.0(5)	0.0(4)	0.0(3)	0.0(5)	0.0(5)	0.0(3)	0.08(12)
373	0.0(4)	0.0(4)	0.0(4)	0.0(4)		0.0(5)	0.0(4)	0.25(4)	0.09(11)
374	0.0(2)	0.0(2)	0.0(4)	0.0(2)	0.0(2)		0.0(3)	0.0(3)	0.0(4)
375	0.33(3)	0.0(3)	0.0(3)	0.0(3)	0.0(3)		0.0(4)	0.20(5)	0.0(5)
376		0.0(2)	0.0(3)		0.0(2)	0.0(3)	0.0(3)	0.0(2)	0.0(4)
377		0.0(2)	0.0(2)	0.0(3)	0.0(2)		18.50(2)	0.0(2)	3.33(3)
378	0.50(2)	0.50(2)	1.50(2)	1.00(3)			9.50(2)	23.00(2)	17.00(3)
379			1.50(2)	3.33(3)			38.00(2)	8.50(2)	10.67(3)
380		7.50(2)	1.67(3)	2.00(2)			7.00(2)		3.00(2)
381	1.00(3)	1.00(4)	0.0(3)	2.50(4)	1.42(2)		6.50(2)	13.33(3)	2.33(3)
382	0.0(3)	0.0(4)	0.0(3)	0.0(3)		0.0(2)	0.33(3)	0.0(3)	0.0(3)
383	0.50(2)	0.0(2)	0.0(2)	0.0(2)		0.0(3)	0.0(3)	0.0(2)	0.0(3)
TOTAL NUMBER	367777	692455	1031244	88526	226225	1618558	1245513	954011	1432235

Average Weight per set

357			1.20(2)				7.26(2)		6.50(3)
358		2.95(4)	2.42(3)				6.02(2)		1.13(2)
359		8.47	20.88(3)			43.28(3)	1.82(3)		2.72(4)
360		0.11(4)			0.0(4)	1.36(4)	0.17(4)	2.61(4)	3.23(9)
361	0.0(2)	0.0(3)	0.0(4)	0.0(4)	1.46(4)	0.0(5)	0.45(3)	0.0(4)	0.14(8)
362	1.82(2)	0.0(4)	0.0(5)	0.0(4)	0.0(3)	0.0(5)	0.0(5)	0.0(3)	0.08(12)
373	0.0(4)	0.0(4)	0.0(4)	0.0(4)		0.0(5)	0.0(4)	0.31(4)	0.08(11)
374	0.0(2)	0.0(2)	0.0(4)	0.0(2)	0.0(2)		0.0(3)	0.0(3)	0.0(4)
375	0.30(3)	0.0(3)	0.0(3)	0.0(3)	0.0(3)		0.0(4)	0.09(5)	0.0(5)
376		0.0(2)	0.0(3)		0.0(2)	0.0(3)	0.0(3)	0.0(2)	0.0(4)
377		0.0(2)	0.0(2)	0.0(3)	0.0(2)		13.17(2)	0.0(2)	1.29(3)
378	1.13(2)	0.45(2)	1.36(2)	1.13(3)			4.81(2)	11.81(2)	7.57(3)
379			0.68(2)	2.88(3)			14.30(2)	4.77(2)	5.60(3)
380		5.56(2)	2.12(3)	1.82(2)			6.81(2)		4.20(2)
381	0.45(3)	0.91(4)	0.0(3)	1.99(4)	1.08(2)		5.45(2)	11.35(3)	2.57(3)
382	0.0(3)	0.0(4)	0.0(3)	0.0(3)		0.0(2)	0.61(3)	0.0(3)	0.0(3)
383	0.68(2)	0.0(2)	0.0(2)	0.0(2)		0.0(3)	0.0(3)	0.0(2)	0.0(3)
TOTAL WT.(TONS)	432	409	754	78	218	1674	768	973	1165

TABLE 5.

A.T. Cameron 30 — Average Number Per Set

Stratum	ATC 207-208-209 1973	ATC 233 1975	ATC 245 1976	ATC 263 1977	ATC 277 1978	ATC 291 1979	ATC 303 1980
329	0.0(2)		46.00(2)	1.33(3)	1.40(5)	0.17(6)	0.0(2)
330	0.17(6)	0.33(3)	0.0(3)	0.0(3)	0.67(6)	2.29(7)	0.0(2)
331	0.0(2)	0.0(2)	0.0(2)		6.50(2)	2.67(3)	7.00(2)
332		7.00(2)	16.33(3)	20.00(3)	23.00(3)	1.25(4)	25.00(2)
333		1.00(2)	5.50(2)	0.50(2)	5.00(3)	1.50(2)	7.00(2)
334			2.50(2)	0.50(2)	6.67(3)	1.00(3)	4.00(2)
335	0.0(2)		6.67(3)		3.50(2)	0.0(2)	14.33(3)
336	1.67(3)	2.50(2)	25.50(2)	8.00(2)	6.50(2)	1.00(4)	27.00(2)
337	4.00(3)	1.33(3)	7.50(2)	4.50(2)	4.00(2)	0.0(4)	3.67(3)
338	16.20(5)	7.50(2)	10.33(3)	8.00(4)	0.20(5)	0.29(7)	6.40(5)
339	3.00(2)	0.0(2)			3.00(2)	3.00(3)	
340		0.0(3)	2.00(6)	0.0(3)	0.50(2)	4.29(7)	0.0(2)
351	0.20(5)	0.74(4)	0.0(4)	0.20(5)	0.0(5)	1.00(11)	0.80(10)
352	0.20(5)	4.78(4)	0.25(4)	0.20(5)	0.25(4)	0.83(6)	4.36(11)
353	24.33(3)	8.00(3)	13.00(2)	11.33(3)	12.33(3)	1.80(5)	11.50(4)
354	32.00(3)		20.00(3)	2.50(2)		4.00(4)	20.67(3)
355	0.50(2)	4.18(2)	6.50(2)			1.50(4)	8.00(2)
356	1.50(2)					1.00(2)	48.00(2)
TOTAL NUMBER	6333216	3666412	11891271	4542014	4237055	2009209	6911809

TABLE 6.

A.T. Cameron 30 — Average Weight Per Set

Stratum	ATC 207-208-209 1973	ATC 233 1975	ATC 245 1976	ATC 263 1977	ATC 277 1978	ATC 291 1979	ATC 303 1980
329	0.0(2)		29.96(2)	1.36(3)	0.96(5)	0.04(6)	0.0(2)
330	0.15(6)	0.15(3)	0.0(3)	0.0(3)	0.42(6)	1.62(7)	0.0(2)
331	0.0(2)	0.0(2)	0.0(2)		6.14(2)	0.76(3)	6.25(2)
332		3.40(2)	12.41(3)	9.69(3)	10.76(3)	0.40(4)	15.50(2)
333		0.68(2)	1.59(2)	0.23(2)	1.51(3)	0.34(2)	3.25(2)
334			1.36(2)	0.11(2)	1.36(3)	0.38(3)	1.75(2)
335	0.0(2)		4.62(3)		0.79(2)	0.0(2)	7.17(3)
336	0.61(3)	1.25(2)	15.89(2)	6.81(2)	1.59(2)	0.28(4)	12.50(2)
337	2.80(3)	0.68(3)	6.54(2)	3.63(2)	1.25(2)	0.0(4)	2.17(3)
338	13.26(5)	5.90(2)	10.74(3)	3.63(4)	0.14(5)	0.32(7)	4.40(5)
339	2.95(2)	0.0(2)			2.92(2)	2.42(3)	
340		0.0(3)	2.19(6)	0.0(3)	0.57(2)	3.15(7)	0.0(2)
351	0.41(5)	0.67(4)	0.0(4)	0.32(5)	0.0(5)	0.91(11)	0.65(10)
352	0.09(5)	2.83(4)	0.17(4)	0.23(5)	0.34(4)	0.87(6)	3.14(11)
353	18.77(3)	7.42(3)	11.80(2)	8.78(3)	11.36(3)	1.59(5)	7.50(4)
354	22.40(3)		14.07(3)	2.27(2)		1.19(4)	8.50(3)
355	0.23(2)	2.72(2)	4.99(2)			0.45(4)	2.75(2)
356	0.91(2)					0.68(2)	27.50(2)
Total Wt. (Tons)	4899	2609	9025	2808	2760	1425	4309

TABLE 7.

30 Witch Biomass (metric tons) per stratum 1975-1980

Year	Stratum 330	332	333	336	337	338	340	351	352	353	Yearly totals over the 10 selected strata
Area (Sq. Mi.)	2089	1047	151	121	948	1898	1716	2520	2582	1282	
ATC 233 1975	24	268	8	11	48	841	0	126	548	714	2587
ATC 245 1976	0	975	18	144	465	1531	283	0	33	1136	4585
ATC 263 1977	0	761	26	62	258	517	0	60	44	845	2550
ATC 277 1978	65	845	17	14	89	19	73	0	66	1094	2283
ATC 291 1979	254	31	39	3	0	46	405	172	169	153	1236
ATC 303 1980	0	1218	37	114	154	627	0	123	607	722	3602
Strata totals over 6 years	343	4099	86	348	1015	3582	761	481	1467	4662	16844

30 Witch ('000's) Numbers per Stratum 1975-1980

Area (Sq. Mi)	2089	1047	151	121	948	1898	1716	2520	2582	1282	
ATC283 1975	52.3	550.1	11.3	22.7	94.9	1068.5	0	139.4	925.0	769.9	3634.1
ATC 245 1976	0	1283.7	62.3	231.6	533.7	1472.2	257.6	0	48.4	1251.0	5140.5
ATC 263 1977	0	1571.8	5.7	72.7	320.2	1139.8	0	37.8	38.7	1090.6	4277.3
ATC 277 1978	104.5	1807.6	56.7	59.0	284.6	28.5	64.4	0	48.4	1186.9	3640.6
ATC 291 1979	358.4	98.2	17.0	9.1	0	40.7	552.0	189.2	161.4	142.3	1568.3
ATC 303 1980	0	1964.8	79.3	245.2	260.9	911.8	0	151.3	845.1	1106.7	5565.1
Strata totals over 6 years	515.2	7276.2	232.3	640.3	1494.3	4461.5	874.0	517.7	2067.0	5547.4	23,825.9

Table 8. A.T. Cameron 263, 1977, 3Ø Witch (Pop. Nos. ('000's)

Age \ Strata	330	332	333	336	337	338	340	351	352	353	Total
					Male						
7		11.6									11.6
8		13.1		3.0	5.9	5.9					27.9
9		192.6		3.5	24.8	67.0				6.3	294.2
10		233.6		7.7	29.0	168.1				36.5	474.9
11		318.6		7.8	52.2	241.7				118.6	738.9
12		165.1		3.9	19.7	103.4				180.0	472.1
13		67.9		1.4	10.7	76.3				223.2	379.5
14		10.5				14.2				44.9	69.6
15		8.7									8.7
Total	0.0	1021.7	0.0	27.2	142.3	676.7	0.0	0.0	0.0	609.5	2477.4
					Female						
4						71.2					71.2
5						-					-
6						-					-
7		5.2				7.1					12.3
8		14.8				10.4					25.2
9		36.6		0.7		31.6					68.9
10		79.1		1.1		39.1				5.8	125.1
11		146.4	0.3	6.8	16.3	136.6			2.8	29.6	338.8
12		118.9	0.8	6.8	33.3	97.1		2.4	8.3	50.1	317.7
13		115.7	3.3	10.2	89.4	53.3		2.4	16.6	120.2	411.1
14		20.8	0.5	6.6	21.8	16.6		9.5	8.3	97.2	181.3
15		10.7	0.8	6.6	14.6			9.5	-	60.1	102.3
16		1.9		6.6	2.5			14.2	2.8	107.5	135.5
17										10.7	10.7
18											
Total	0.0	550.1	5.7	45.4	177.9	463.0	0.0	37.8	38.7	481.2	1799.8

Table 9. A.T. Cameron 277, 1978, 3Ø Witch (Pop. Nos. '000's)

Age \ Strata	330	332	333	336	337	338	340	351	352	353	Total
Male											
4											
5											
6											
7		23.2	2.7	4.3	16.8					7.1	54.2
8		80.0	4.5	4.5	11.9					22.3	123.2
9	9.6	181.5	5.0	7.3	16.8					42.3	262.5
10	19.9	216.5	7.0	1.5	17.8					153.8	416.5
11	8.7	209.1	3.5	7.1	4.0					123.4	355.8
12	9.6	130.0	2.3	2.5	4.0					105.8	254.2
13	2.2	13.1	1.4							30.2	46.9
14	2.2	10.9								36.9	50.0
15										23.5	23.5
Total	52.3	864.5	26.4	27.2	71.2	0.0	0.0	0.0	0.0	545.3	1586.5
Female											
5				4.5							4.5
6				-							-
7		8.7	2.5	3.0	11.9						26.1
8		97.6	3.8	3.4	14.8					18.3	137.9
9		87.3	5.0	1.5	11.9					10.7	116.4
10	2.9	279.9	5.5	4.7	11.9					56.1	361.0
11	10.6	264.6	4.6	9.2	14.8					123.7	427.5
12	28.8	164.5	5.6	4.1	5.9	7.1				201.0	417.0
13	7.7	45.1	1.7	0.8		9.5				116.7	181.5
14	2.4	31.5	0.9	0.4		7.1			24.2	47.0	113.5
15		11.9	0.3			2.4			-	65.3	79.9
16		4.4	0.3			2.4			24.2	2.7	34.0
Total	52.3	995.5	30.2	31.8	71.2	28.5	0.0	0.0	48.4	641.5	1899.4

Table 10. A.T. Cameron 291, 1979, 3Ø Witch (Pop. Nos. '000's)

Age \ Strata	330	332	333	336	337	338	340	351	352	353	Total
Male											
7		1.8		0.2							2.0
8		16.9	4.4	5.2							26.5
9		40.2	1.3	1.4			52.5			1.6	97.0
10	87.5						131.8	28.6	8.5	55.4	311.8
11	114.3					12.7	134.9	77.0	19.7	35.4	394.0
12	44.6					7.6	67.3	49.2	7.0	3.8	179.5
Total	246.4	58.9	5.7	6.8	0.0	20.4	386.4	154.8	35.2	96.2	1010.8
Female											
5											
6											
7			0.4								0.4
8			3.1								3.1
9			7.5	0.1							7.6
10	12.2	23.4	0.4	2.1			31.9				70.0
11	36.7	15.9				3.7	89.3	22.2	29.5	35.8	233.1
12	16.3					14.8	26.0	12.1	23.3	39.4	131.9
13	2.0					1.9	18.4			1.7	24.0
Total	67.2	39.3	11.3	2.3	0.0	20.4	165.6	34.4	52.8	77.0	470.3

Table 11. 3Ø Witch (Pop. Nos. '000's)

Survey Age	ATC 263 1977	ATC 277 1978	ATC 291 1979	1977+ 1978	$Log_e N$
		Male			
7	11.6	54.2	2.0	65.8	4.187
8	27.9	123.2	26.5	151.1	5.018
9	294.2	262.5	97.0	556.7	6.322
10	474.9	416.5	311.8	891.4	6.793
11	738.9	355.8	394.0	1094.7	6.998
12	472.1	254.2	179.5	726.3	6.588
13	379.5	46.9		426.4	6.055
14	69.6	50.0		119.6	4.784
15	8.7	23.5		32.2	3.472
Total	2477.4	1586.5	1010.8		

Catch curve

Ages	11-15	13-15
r^2	0.94	1.00
Intercept	17.09	22.85
slope	-0.89	-1.29

Paloheimo Z

$Z_{10+} = 1.07$

$Z_{11+} = 1.48$

		Female			
4	71.2			71.2	4.265
5	-	4.5		4.5	1.504
6	-	-		-	-
7	12.3	26.1	0.4	38.4	3.648
8	25.2	137.9	3.1	163.1	5.094
9	68.9	116.4	7.6	185.3	5.222
10	125.1	361.0	70.0	486.1	6.186
11	338.8	427.5	233.1	766.3	6.642
12	317.7	417.0	131.9	734.7	6.599
13	411.1	181.5	24.0	592.6	6.385
14	181.3	113.5		294.8	5.686
15	102.3	79.9		182.2	5.205
16	135.5	34.0		169.5	5.133
17	10.7			10.7	2.370
Total	1799.8	1899.4	470.3		

Catch curve

Ages	11-17	11-16	13-16
r^2 =	0.77	0.93	0.90
Int. =	13.90	10.73	11.75
Slope =	-0.60	-0.36	-0.42

Paloheimo Z

$Z_{11+} = 0.49$

$Z_{12+} = 0.91$

$Z_{13+} = 1.12$

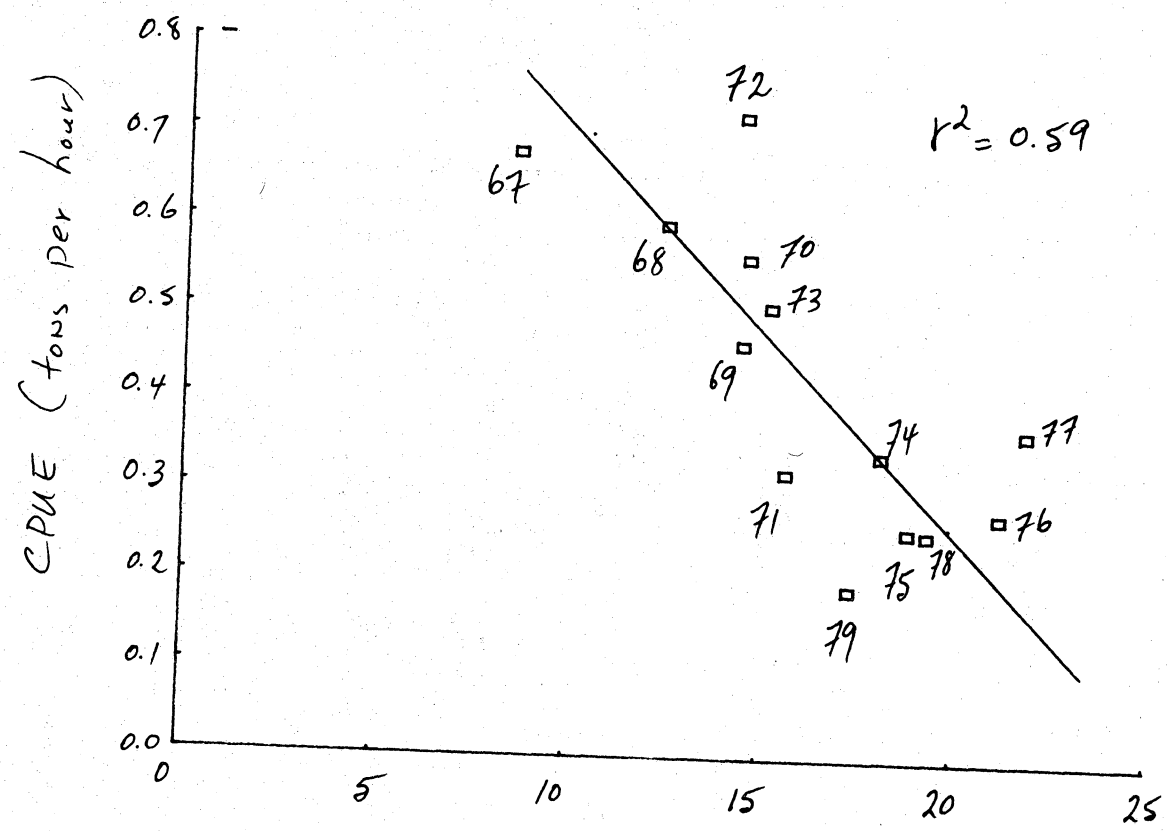
CPUE (tons per hour)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
EFFORT ('000's HOURS)
$r^2 = 0.59$
67
68
69
70
71
72
73
74
75
76
77
78
79

Fig 1.

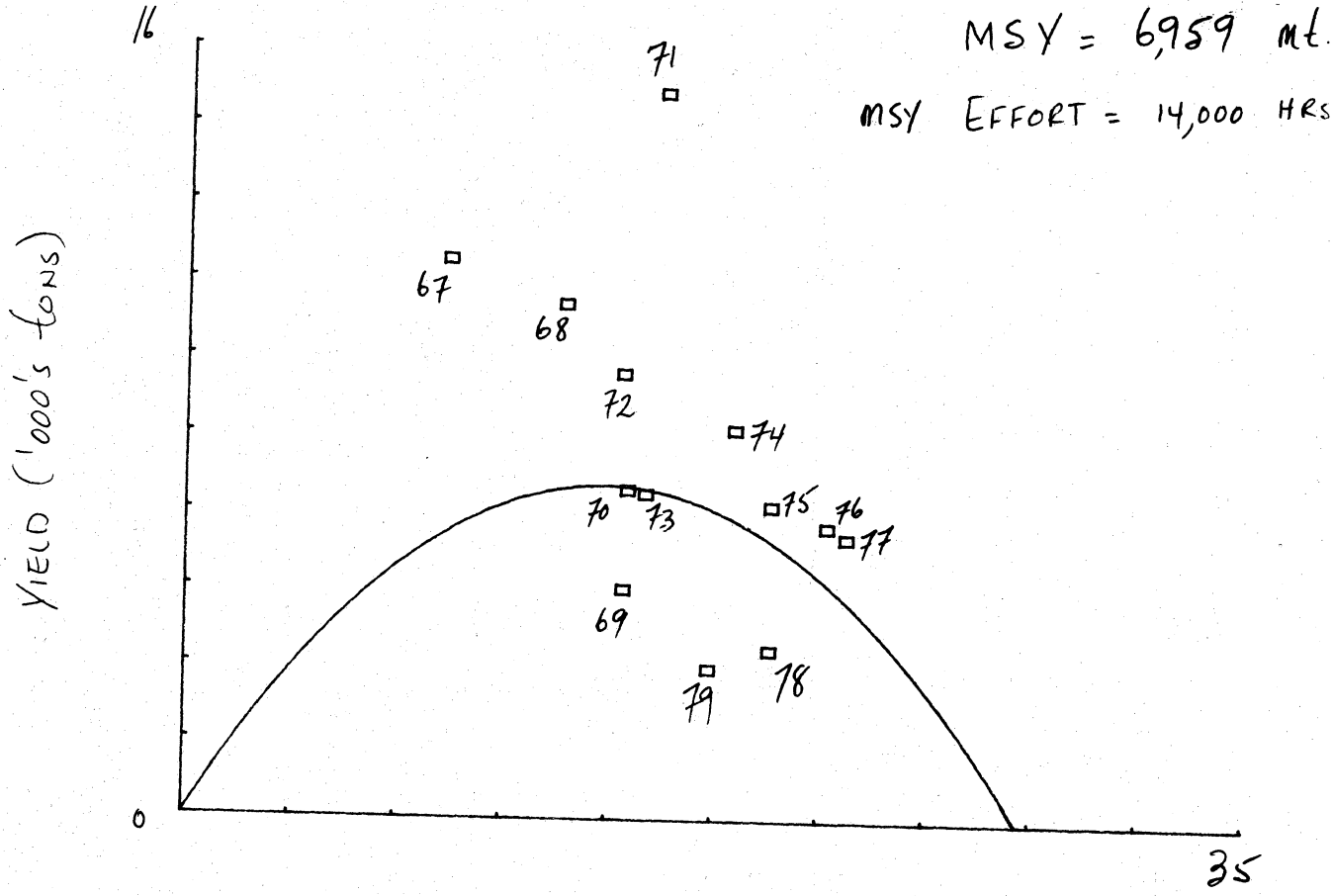
16
0
35
YIELD ('000's tons)
EFFORT ('000's HRS.)
MSY = 6,959 mt.
MSY EFFORT = 14,000 HRS
67
68
69
70
71
72
73
74
75
76
77
78
79

Fig 2.

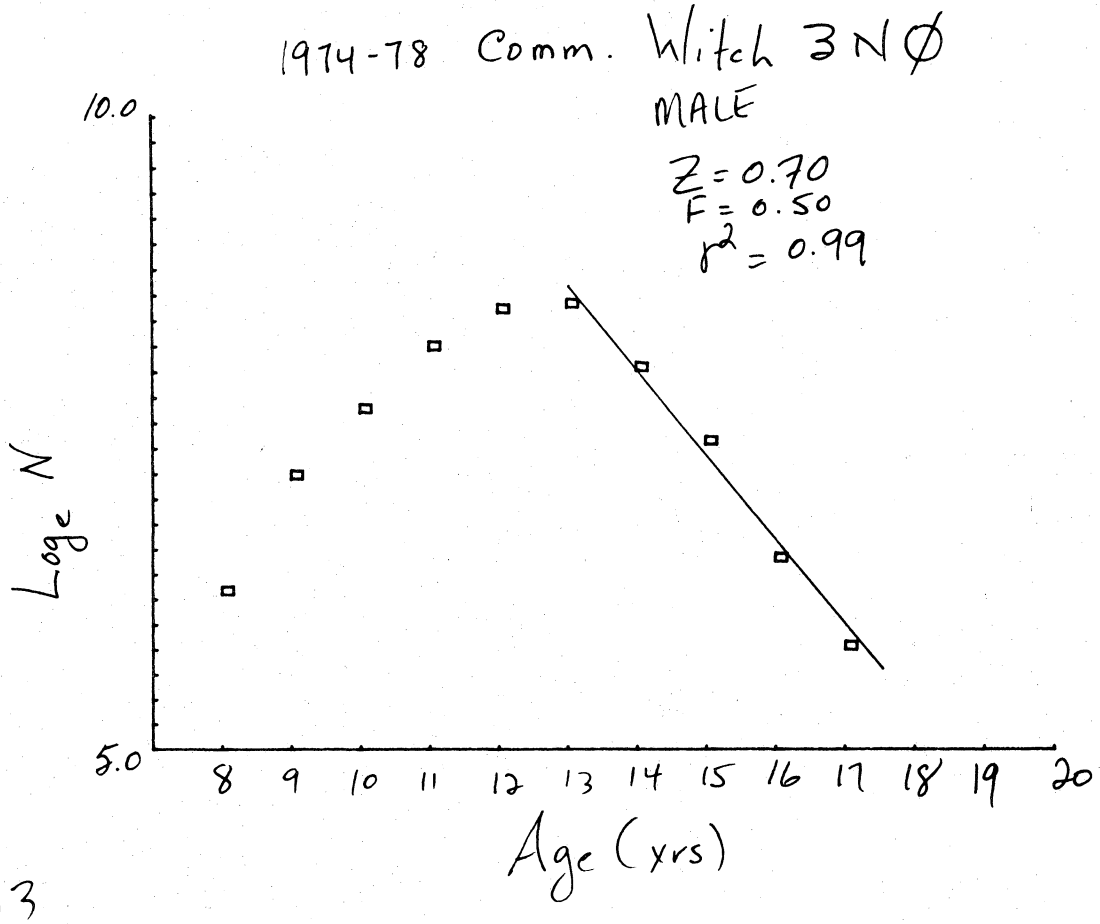
1974-78 Comm. Witch 3NØ
MALE
Z = 0.70
F = 0.50
r² = 0.99
10.0
5.0
Loge N
8 9 10 11 12 13 14 15 16 17 18 19 20
Age (yrs)

Fig 3

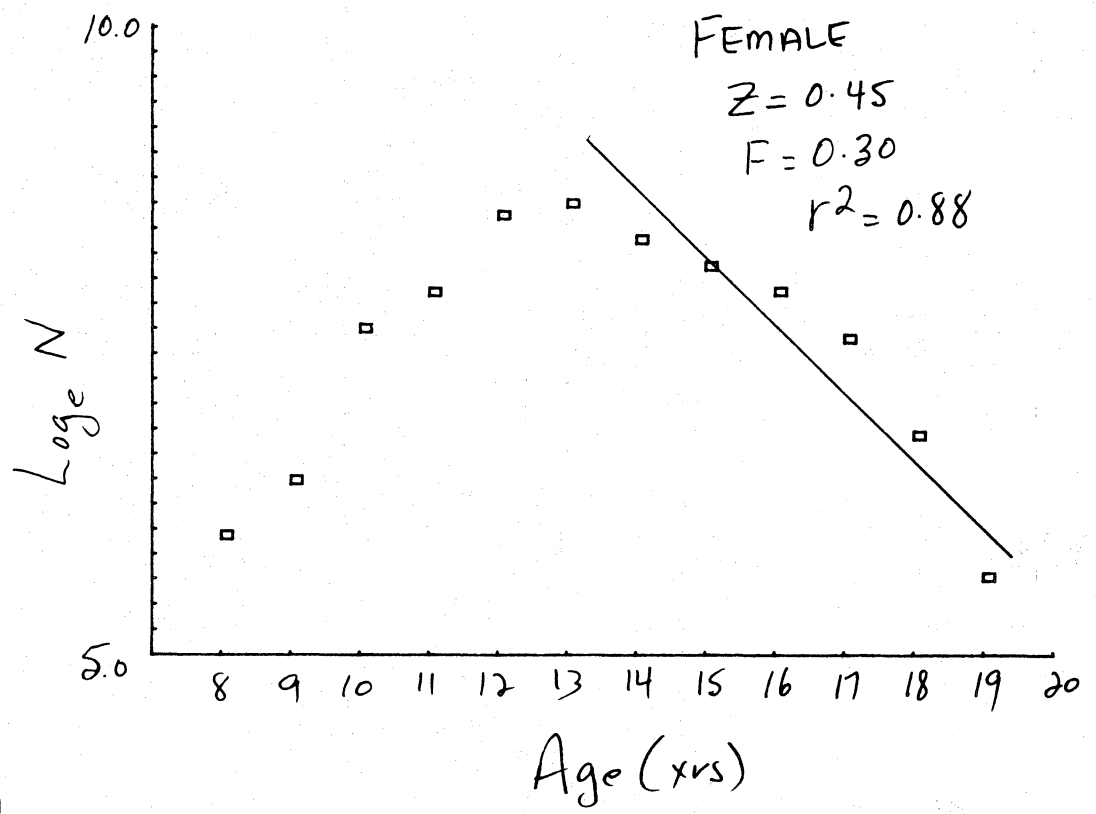
1974-78 Comm. Witch 3NØ
FEMALE
Z = 0.45
F = 0.30
r² = 0.88
10.0
5.0
Loge N
8 9 10 11 12 13 14 15 16 17 18 19 20
Age (yrs)

Fig 4

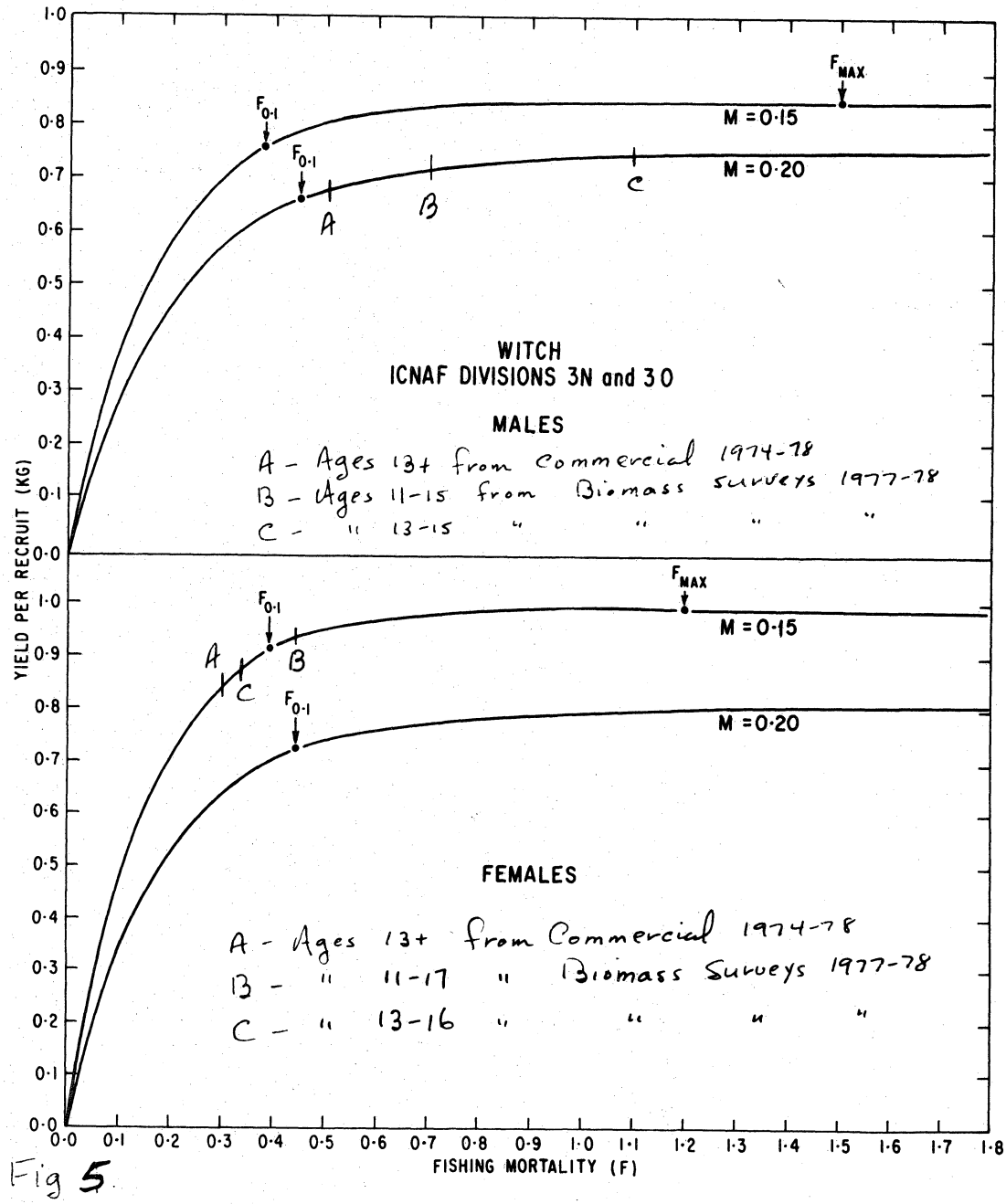
WITCH
ICNAF DIVISIONS 3N and 3O
MALES
A - Ages 13+ from Commercial 1974-78
B - Ages 11-15 from Biomass surveys 1977-78
C - " 13-15 " " " "
FEMALES
A - Ages 13+ from Commercial 1974-78
B - " 11-17 " Biomass Surveys 1977-78
C - " 13-16 " " " "
M = 0·15
M = 0·20
F0·1
FMAX
YIELD PER RECRUIT (KG)
FISHING MORTALITY (F)

Fig 5

1977 - 78 RES. WITCH 3NØ
MALE

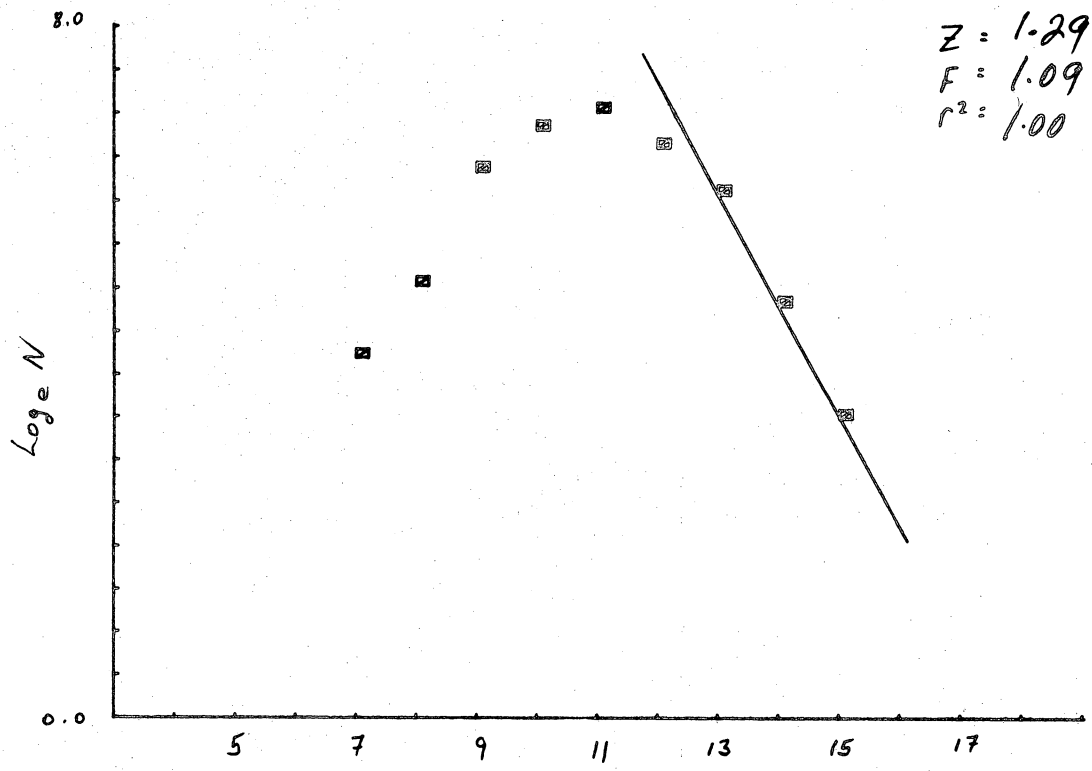

Fig 6.

AGE (YRS)

1977 - 78 RES. WITCH 3NØ
FEMALE

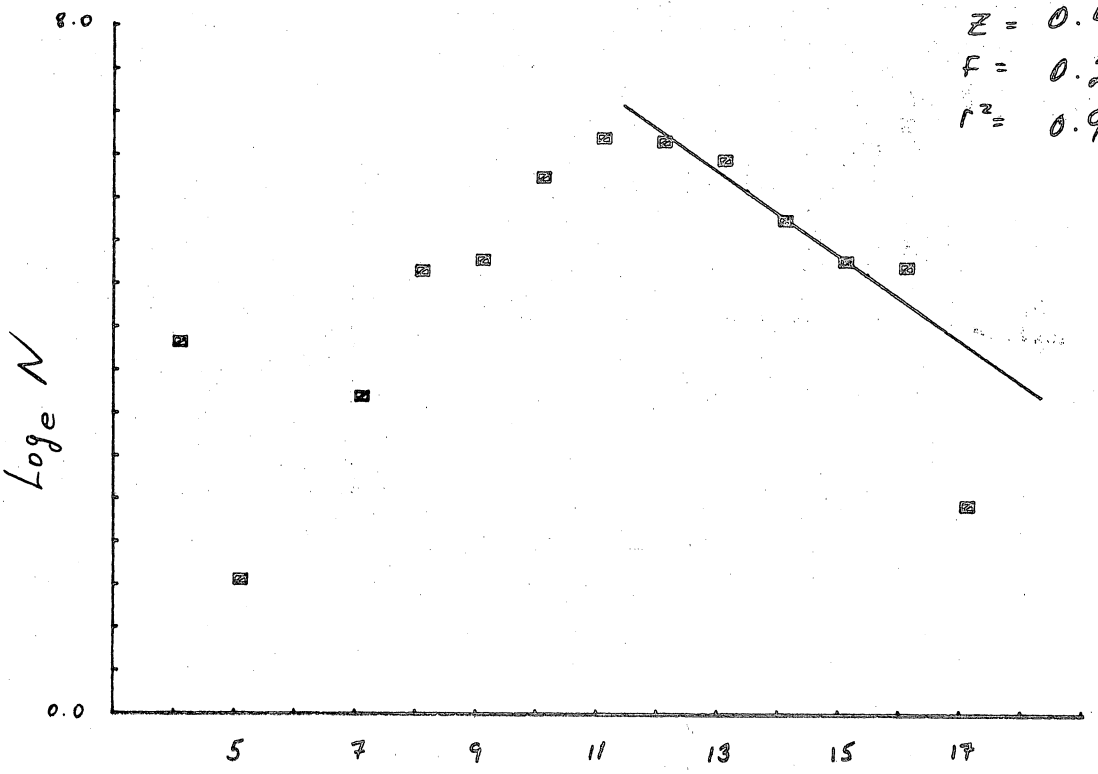

Fig 7.

AGE (YRS)