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An assessment of 4VWX + 5 pollock

Lynn Cleary
Marine Fish Division
Resource Branch
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

INTRODUCTION

Pollock *(Pollachius virens)* is increasing in commercial importance in Subareas 4 and 5 of the ICNAF convention area. Successive TAC of 50,000 (Div. 4X and Subarea 5) (ICNAF, 1973a), 55,000 (Div. 4VWX and SA 5) (ICNAF, 1973b) and 30,000 tons (Div. 4VWX and SA 5) were approved for 1973, 1974-75-76 and for 1977.

Nominal catch data (Table 1) indicates the center of distribution of pollock to lie in Division 4X. Total landings have been fairly constant since 1973 (Fig. 1, Table 2). Canada is the main harvester of the pollock fishery, followed by the United States. Canadian catch reaches its peak in summer whilst American catch is maximum in autumn. More than 82% of the Canadian catch was caught in SA 4, while over 90% of the American catch was taken in SA 5. Catches by other countries have fluctuated between 0% (1962) and 39% (1971) of the total catch (Fig. 2, Table 3).

Although there is evidence of many possible spawning areas on the Scotian Shelf and off Cape Breton Island (Steele, 1963), at present, the information available is not adequate to provide a basis for stock delineation. We will thus consider pollock of SA 4 and 5 as a single stock in order to assess the population.

Catch Composition

Length frequency sampling of the pollock in Div. 4VWX and SA 5 has been very limited. Canadian samples have been collected since

1961, but from 1961 to 1973 seasonal coverage was incomplete. There have been no foreign samples on pollock since 1972. Therefore, Canadian samples were applied to Canadian and foreign fleet catch from 1973-77 to prorate number at age. Samples from otter trawl and gillnets were applied to their respective catches in 1976 and 1977. American landings were prorated on Canadian and American samples.

Removals of age for all countries are given in Table 4. From these data, it seems that the 1971 year class was a relatively strong one and succeeding year classes are getting progressively weaker.

Catch rates as population abundance indices

Examination of volume of pollock catch by various gear and vessel tonnage class in the Canadian fleet indicates that stern otter trawlers of 501-900 GRT have had the highest volume of catch in the period 1973-76 (Tables 5 and 6).

In order to minimize the variations of catch per unit of effort due to availability of the fish rather than to a real population abundance fluctuation, only a short period of the year should be considered in the calculations. Since in the Canadian fishery both landings and effort are maximum during the summer (Fig. 3), catch rates were calculated with data from the three months June to August only. Since there was very little Canadian directed fishery in pollock previous to 1974, a method similar to that used by Chikuni (1976) was used to adjust catch rates.

Briefly, the method consists of doing a regression of the catch per unit of effort (CPUE) versus the proportion (%) of the studied species in the total catch. A standard percentage (75%), representing a directed fishery was then chosen, and a corrected CPUE calculated (Table 7A).

Additional indices of population abundance calculated were the mean catch per unit of effort of pollock using total effort for all species of groundfish, and the mean catch per unit of effort for statistics where pollock represented 50% or more of the total catch.

American landings provided two additional abundance indices. These are catch rate (mt/day fished) for trips of otter trawlers 0-50 GRT and 150-500 GRT for which 50% or more of the total landed weight consisted of pollock.

All the commercial catch rates, except for the Canadian total groundfish series agree in showing a gradual decline of population abundance since 1973, and a drastic increase in 1977 (Fig. 4 and Table 7A).

The Canadian summer cruise indices (No. per tow) follow generally the same pattern as the commercial indices, but with less abrupt changes from one year to the next.

The American research cruise catch rates are high in contrast with all other indices in 1977, showing a sudden decline. The same fact was noted in the haddock fishery (O'Boyle, personal communication) and was related to an availability problem rather than to real facts.

Total mortality

Total mortality coefficients were calculated with the commercial catch at age and both Canadian research and commercial catch rates (Tables 8 and 9). Average mortality for the last four years was 0.50 and 0.60 respectively. No significant correlation could be found between Z and effort.

Average mortality rate calculated with research catch per tow data for 1970-1977 was 0.36 for Canadian summer cruises and 0.17 for American autumn cruises (Tables 10 and 11).

Maturity at age

Maturity at age was calculated using the Canadian summer research cruise data from 1970-1976. Since the growth rate of pollock is quite similar for males and females (Steele, 1963) data were grouped to combine sex (Table 12). Pollock is fully mature at 7 years old. This result is quite similar to what Steele (1963) found, although the percentage of maturity is different for lower ages.

Length frequency and weight at age

Annual length frequencies of the commercial samples are shown in Figure 5. There has been a definite shift in the modal length from 67-73 cm in 1972 to 49 cm in 1977. The result was then weighted by the numbers of fish at age caught during the month (Table 13).

The shift of the fishery towards smaller fish could be explained by the fact that in 1977 landings were relatively high during the first quarter of the year. For this period of the year, catch proportion was higher in 1977 than in 1976 (Figs. 6 and 7) and more younger fish were caught.

Partial recruitment to the fishery

Partial recruitment to the fishery was determined by plotting a mean F at age obtained by cohort analysis for 1973-74, full recruitment assumed at age 5, and partial recruitment at age 2 = 0.017, age 3 = 0.267, and age 4 = 0.852, calculated (Fig. 8).

Cohort analysis

Since landings were quite constant for the last three years

and the abundance indices tend to show an increase in 1977, we assumed that the fishing mortality in 1977 was not higher than in 1976 (Table 14). Cohort analysis were thus run until a value of initial F (=0.3) would give equal fully recruited F for 1976 and 1977.

To substantiate this result, a starting F value was also found by dividing the 1977 effort by the mean catchability of 1973 and 1974. The initial F value stabilized around 0.3

With an initial F = 0.3, the correlation between recruitment to the population and Canadian summer cruise catch rate (age 2 and 3) was .94 g (Fig. 9).

Yield per recruit

Using the 1977 mean weight at age, and assuming a natural mortality of 0.2, the yield per recruit relationship gives an $F_{0.1}$ = 0.227 and F_{max} = 0.386 (Fig. 10).

Catch projection

The projection of future catch was executed using $F_{0.1}$ and F_{max} (Table 15). The TAC for 1978 being 30,000 mt, a fishing mortality of 0.227 in the next two years would allow the increase of biomass. In the same conditions, fishing at F_{max} would result in a slight decrease in biomass in 1981.

Catch and effort curve

The catch and effort curve of pollock has been fitted for 1972-77 (Fig. 11). According to the curve, the MSY would be around 42,000 mt. Fishing at 2/3 MSY would provide a catch of 38,000 mt.

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Table 1. Pollock landings (MT, round fresh) for Divs. 4VWX, Subarea 5, and Statistical Area 6, 1960-76

YEAR	4Vn	4Vs	4W	4X	TOTAL 4VWX	5Y	5Ze	5Zw	TOTAL 5Z	5NK	TOTAL SA 5	SA 6	TOTAL
1960	691	811	8354	20132	29988	6545	-	-	3834	18	10397	-	40385
61	811	1053	13167	14321	29352	5017	-	-	3177	25	8219	-	37571
62	554	738	12045	19624	32961	2560	-	-	3576	15	6151	-	39112
63	400	274	9152	20645	30471	2168	-	-	3947	10	6125	116	36712
64	337	137	12488	19283	32245	1754	-	-	7250	-	9004	4	41253
1965	147	1058	13134	13390	27729	1933	-	-	7065	-	8998	2	36729
66	226	562	11040	12648	24476	953	-	-	8846	-	9799	48	34323
67	147	510	5836	8290	14783	1728	-	-	6790	14	8532	2	23319
68	256	757	5954	10656	17623	1416	3724	82	3806	-	5222	4	22849
69	91	209	3938	10983	15221	4635	5025	162	5187	-	9822	-	25043
1970	130	519	2952	8194	11795	6281	5157	123	5280	-	11561	415	23771
71	214	317	1802	9739	12072	7016	7096	142	7238	58	14312	891	27275
72	102	495	3419	16190	20206	6419	6519	51	6570	-	12989	24	33219
73	170	834	5871	23225	30100	5202	6235	1618	7853	-	13055	21	43176
74	68	239	4740	20362	25409	6106	6233	5	6238	-	12344	49	37802
1975	179	620	5697	18668	25164	6015	7848	3	7851	-	13866	5	39035
76	52	1050	3424	19700	24226	6441	6915	11	6926	12	13379	3	37608
77	167	1181	6623	14554	22525	8275	7759	79	7838	36	16149	33	38707

Table 2. Pollock landings (mt round fish) by months and country for Div. 4VWX-Sub 5.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total[a]
						CANADA							
1972	204	993	296	930	1004	3084	3718	1192	1755	2188	2191	467	18022
1973	498	981	1521	2922	2135	4785	3239	3403	2331	2181	1955	1039	26990
1974	288	187	869	1012	1986	3730	5073	2206	2202	1634	2461	3327	24975
1975	333	230	475	2021	1524	2920	2736	3691	2312	2833	2993	4480	26548
1976	297	263	445	1498	2604	4270	3814	2327	2347	1669	1413	2621	23568
1977	1067	1712	2187	1859	1006	2184	2103	2004	2310	1771	2313	4464	24980
1978[b]	2491	3242	1804	1846	3063	2320	897						
						U.S.A.							
1972	455	318	228	229	200	394	329	294	314	488	1082	1397	5728
1973	419	313	311	406	331	418	335	302	262	573	1111	1519	6300
1974	946	558	508	650	479	388	644	570	480	661	1097	1385	8726
1975	740	721	486	594	477	924	684	743	765	598	1108	1061	9314
1976	706	658	501	665	936	1035	985	800	1125	669	813	1305	10861
1977	1015	662	463	816	1063	1036	1351	1152	941	925	1186	1710	13042
1978													
						OTHERS							
1972	599	481	440	686	538	627	867	270	183	47	385	4278	9445
1973	513	1808	442	966	48	812	117	367	700	407	1996	1689	9865
1974	42	567	165	132	751	235	612	463	412	228	176	268	4051
1975	154	382	311	129	645	339	234	51	195	156	327	245	3168
1976	33	129	273	312	228	265	257	275	659	543	113	89	3176
1977	6	23	49	57	103	48	46	50	121	106	27	16	652
1978													
						TOTAL							
1972	1258	1792	964	1845	1742	4105	4914	1756	2252	2723	3658	6142	33195
1973	1430	3102	2274	4294	2514	6015	3691	5072	3293	3161	5062	4247	43155
1974	1276	1312	1542	1794	3216	4353	6329	3239	3094	2523	3734	4980	37752
1975	1227	1333	1272	2744	2646	4183	3654	4485	3272	3587	4428	5786	39030
1976	1036	1050	1219	2475	3768	5571	5070	3402	4131	2881	2339	4015	37605
1977[c]	2088	2397	2699	2732	2172	3268	3500	3206	3372	2802	3526	6190	38674
1978													

[a] includes NK months of the year

[b] provisional

[c] landings by month prorated

Table 3. Pollock landings (mt round fresh) by country for Division 4VWX, Subarea 5 and Statistical area 6, 1960-77

Year	Canada	Fed. Rep. Germany	Germ. Dem. Rep.	Japan	Spain	USSR	United Kingdom	USA	Other	Total
1960[a]	29,470	-	-	-	783	-	-	10,132	1	40386
1961	26,323	-	-	-	982	-	-	10,265	1	37571
1962	31,721	-	-	-	-	-	-	7,391	-	39112
1963	28,999	126	-	-	-	906	28	6,653	-	36712
1964	30,007	208	-	-	-	4603	374	6,006	55	41253
1965	27,316	71	-	-	1361	2667	11	5,303	-	36729
1966	18,271	-	-	-	2384	9865	12	3,791	-	34323
1967	17,567	-	9	-	1779	644	1	3,312	-	23317
1968	18,062	-	-	-	1128	372	-	3,280	7	22849
1969	15,968	1188	2195	-	1515	227	-	3,943	7	25043
1970	10,753	3233	4710	40	532	527	-	3,976	-	23771
1971	11,757	633	6849	15	912	2216	-	4,890	3	27275
1972	18,022	475	4816	8	616	3495	4	5,729	54	33219
1973	26,990	1124	948	1570	3113	3092	-	6,303	36	43176
1974	24,975	149	2	40	1500	2348	48	8,726	14	37802
1975	26,548	236	96		709	2004	-	9,318	124	39035
1976	23,568	994	24	-	303	1466	-	10,863	390	37608
1977	34,982	368	-	1	-	268	-	13,049	39	38707

a Catches for 1960-76 from ICNAF Statistical Bullentins, vol. 10-26.

b Includes Cuba, Denmark, France, Italy, Iceland and Poland.

c Includes unallocated catch

Table 4. Catch at age (000's) for pollock in division 4VWX - Subarea 5, 1973-1977.

Age (years)	1973	1974	1975	1976	1977
2	1057	631	315	423	155
3	1803	7872	3609	3313	2233
4	5488	3424	8630	4002	4237
5	4332	3076	1644	4154	2560
6	1069	1313	1505	1130	2384
7	850	447	627	1031	1184
8	347	289	191	275	582
9	487	109	86	40	187
10	454	90	116	38	74
11	86	63	106	49	39
12+	30	26	64	85	264

Table 5. Catch of pollock in metric tons by fishing gear for Canadian (Maritimes and Quebec, 4VWX & Sub 5) offshore fishery, 1972-77.

Year	Side Trawl	Stern Trawl	Gillnet	Others
1972	6775.5	8417.9	6.3	196.7
1973	10711.4	11920.7	15.6	32.5
1974	6510.8	13302.7	14.1	17.6
1975	3795	16015.1	176.6	28.2
1976	2710.9	12747.3	950.1	60.8
1977	2096.4	16540.4	491.7	160.2

Table 6. Catch of pollock in metric tons by vessel size for Canadian (Maritimes and Quebec, 4VWX + Sub 5) Stern trawl, 1972-77

	Vessel Size (tons)			
Year	26-50	51-150	151-500	501-900
1972	668	1369.3	764.2	5616.4
1973	2038.7	4234.9	872.9	4774.2
1974	798.3	2163.4	1106.6	9234.4
1975	568.3	2482.4	880.7	12083.7
1976	680.7	2993.9	379.1	8693.6
1977	777.9	2449.5	297.7	13015.3

Table 7A. Pollock research and commercial catch per unit of effort in Division 4VWX-5

	1972	1973	1974	1975	1976	1977
Research Cruises						
Canadian summer bottom trawl (No.)	2.27	2.55	2.31	1.2	2.76	6.28
American autumn bottom trawl (No.)	2.2	1.6	0.9	0.7	3.7	1.9
American spring bottom trawl	7.0	5.0	2.1	1.7	1.8	1.6
Commercial						
Canadian stern trawl 501-900 GRT						
CPUE for 50% or more of total catch (mt/hr)	0.63	0.85	0.74	0.67	0.57	0.98
CPUE at 75% of total catch (mt/hr)	0.80	0.71	0.53	0.57	0.36	0.93
CPUE for total groundfish effort (mt/hr)	0.16	0.18	0.32	0.35	0.22	0.76
American Otter Trawl						
0-50 GRT (mt/day)	8.44	11.59	8.76	5.25	4.67	6.87
501-900 GRT (mt/day)	7.68	7.77	7.61	6.27	6.56	8.15

Table 7B. Effort calculated with total landings divided by catch rates for Pollock.

Effort Estimated From	1972	1973	1974	1975	1976	1977
Research Cruises						
Canadian summer bottom trawl (tow)	14,623	16,924	16,343	32,525	13,625	6,064
American autumn bottom trawl (tow)	15,089	26,972	41,948	55,757	10,164	20,042
American summer bottom trawl (tow)	4,742	8,631	17,978	22,959	20,892	23,799
Commercial						
Canadian stern trawl 501-900 GRT						
CPUE for 50% or more of total catch (hr)	52,690	50,771	51,018	58,254	65,974	38,856
CPUE at 75% of total catch (hr)	41,494	60,782	71,232	68,474	104,458	40,945
CPUE for total groundfish effort (hr)	207,469	239,750	117,978	11,514	170,932	39,666
American Otter Trawl						
0-50 GRT (mt/day)	3,933	3,723	4,310	7,434	8,053	5,543
501-900 GRT (mt/day)	4,322	5,554	4,961	6,225	5,733	4,672

Table 8. Total mortality coefficient (Z) for pollock calculated from the commercial catch at age data and effort estimated from Canadian summer bottom trawl research CPUE.

AGE	1973-74	1974-75	1975-76	1976-77
2-3	-1.843	-1.059	-3.384	-2.282
3-4	-.477	.593	-1.135	-.865
4-5	.744	1.418	-.300	-.172
5-6	1.358	1.399	-.657	-.063
6-7	1.037	1.424	-.653	-.665
7-8	1.244	1.535	-.207	-.047
8-9	1.323	1.897	.532	-.233
9-10	1.853	.622	-.215	-1.234
10-11	2.140	.521	-.170	-.645
11-12+	1.361	.669	-.811	-2.303
$\bar{Z}$	1.492	1.233	-.228	-.481

[a]$\bar{Z}$ Calculated for ages 5-6 to 10-11

Table 9. Total mortality coefficient (Z) for pollock calculated from the commercial catch at age data and effort estimated from commercial CPUE.

AGE	1973-74	1974-75	1975-76	1976-77
2-3	-1.852	-1.788	-1.927	-2.602
3-4	-.485	-.136	.323	-1.184
4-5	.735	.690	1.157	-.491
5-6	1.350	.671	.801	-.383
6-7	1.028	.695	.804	-.984
7-8	1.235	.806	1.250	-.366
8-9	1.314	1.168	1.990	-.552
9-10	1.845	-.106	1.243	-1.553
10-11	2.131	-.208	1.288	-.964
11-12+	1.353	-.060	.647	-2.622
$\bar{Z}^a$	1.484	.504	1.229	-.800

[a]$\bar{Z}$ Calculated for age 5-6 to 10-11.

Table 10. Stratified mean catch per tow at age (number) and total mortality coefficient (Z) calculated for pollock in Canadian summer bottom trawl surveys in Div. 4VWX, 1970-77.

Age	1970	1971	1972	1973	1974	1975	1976	1977
1	.007	-	.010	-	.007	-	-	-
2	1.785	.731	.093	.402	.042	.006	.031	.261
3	.430	.609	.199	.374	.942	.018	.199	.781
4	.267	.169	1.249	1.136	.233	.327	.571	.984
5	.194	.039	.383	.418	.286	.276	1.003	2.029
6	.192	.018	.111	.067	.186	.369	.241	1.425
7	.154	.032	.032	.015	.211	.055	.415	.204
8	.099	.011	.055	.038	.093	.099	.153	.360
9	.021	.007	.048	.038	.085	.034	.032	.118
10	-	.022	.036	.002	.052	.004	.034	.062
11	.048	-	.012	.026	.129	.008	.011	.034
12	.013	-	.006	.011	.046	-	.023	.016
13+	-	-	.025	-	-	-	.028	-
Nk	.027	-	.010	-	-	-	.014	.004
Total	3.238	1.638	2.267	2.547	2.312	1.196	2.755	6.278
Z(age 5+)[a]	2.08	-0.95	1.20	-0.23	0.65	-0.12	-0.13	

[a] calculated as $\ln \left[\frac{\Sigma \text{ age 5 and older}}{\Sigma \text{ age 6 and older}}\right]$

Table 11. Stratified mean catch per tow at age (nos) for pollock in Albatross IV autumn bottom trawl survey cruises in Division 4X and 5Y (Strata 24 and 26-42)

AGE	1970	1971	1972	1973	1974	1975	1976	1977
0	0.01	0.03	0.00	0.00	0.00	0.02	0.00	0.00
1	0.14	0.14	0.58	0.04	0.00	0.28	0.04	0.06
2	0.06	0.24	1.02	0.88	0.10	0.07	0.04	0.05
3	0.03	0.07	0.56	0.13	0.34	0.05	0.22	0.03
4	0.10	0.01	0.08	0.22	0.28	0.13	0.82	0.32
5	0.10	0.08	0.09	0.15	0.16	0.06	2.41	0.53
6	0.10	0.12	0.11	0.16	0.12	0.06	0.70	0.47
7	0.05	0.05	0.07	0.11	0.11	0.08	0.45	0.28
8	0.06	0.10	0.07	0.07	0.02	0.06	0.21	0.14
9	0.01	0.03	0.06	0.00	0.03	0.02	0.07	0.11
10	0.03	0.01	0.03	0.18	0.00	0.01	0.01	0.02
11	0.01	0.01	0.03	0.02	0.04	0.01	0.01	0.00
12	0.00	0.02	0.03	0.01	0.00	0.00	0.04	0.03
13	0.04	0.02	0.02	0.05	0.00	0.01	0.09	0.00
14+	0.06	0.08	0.07	0.07	0.02	0.03	0.30	0.15
Σ	0.80	1.01	2.82	2.10	1.22	0.89	5.41	2.19
Z[a]	0.11	0.05	-0.16	0.85	0.65	-1.63	1.33	

[a] $\ln \left[\frac{\Sigma \text{ age 5 and older}}{\Sigma \text{ age 6 and older}}\right]$

TABLE 12. Maturity at age for Pollock in division 4VWX - subarea 5 area Bay of Fundy

AGE (years)	4VWX - 5[a]	Bay of Fundy[b]	
	Sex combined (% mature)	Males (% mature)	Females
2	0	-	-
3	2	0	0
4	36	13	1
5	78	73	45
6	98	95	92
7	100	98	97
8+	100	-	-

[a] from the Canadian summer bottom trawl surveys, 1970-1977

[b] Steele, 1963

Table 13. Weight at age (kg) of pollock in Div. 4VWX + 5

AGE	1973	1974	1975	1976	1977
1	.000	.000	.000	.000	.000
2	.720	.810	.890	.808	.797
3	1.300	1.440	1.470	1.514	1.011
4	1.950	2.180	2.100	2.206	1.553
5	2.810	3.070	2.970	2.929	2.327
6	4.170	4.100	3.950	3.699	3.292
7	5.200	5.100	5.000	4.510	4.444
8	5.930	6.110	6.240	5.217	5.583
9	6.500	6.680	7.070	6.411	6.375
10	7.220	7.270	7.290	7.380	6.902
11	8.980	8.010	7.830	7.424	8.035
12	9.220	8.650	8.880	7.285	8.361
13	9.150	7.340	8.800	7.743	8.533
14	.000	8.680	10.920	7.820	8.316
15	.000	.000	9.290	8.755	9.077
16	.000	.000	.000	7.820	10.995

Table 14. Cohort analysis population numbers and fishing mortality

POPULATION NUMBERS

Age Years	1973	1974	1975	1976	1977
2	56862	31926	35603	39555	34286
3	22762	45598	25568	28864	32002
4	20261	17005	30210	17667	20634
5	9910	11623	10824	16925	10844
6	2878	4194	6733	7374	10098
7	1915	1389	2246	4150	5015
8	1800	799	733	1271	2465
9	1053	1160	393	427	792
10	720	421	851	244	313
11	141	179	263	592	165
12	40	38	90	120	440
	118343	114331	113512	117190	117056

FISHING MORTALITY

Age Years	1973	1974	1975	1976	1977
2	.021	.022	.010	.012	.005
3	.092	.212	.170	.136	.080
4	.356	.252	.379	.288	.256
5	.660	.346	.184	.316	.300
6	.529	.425	.284	.186	.300
7	.674	.440	.369	.321	.300
8	.240	.510	.340	.273	.300
9	.716	.110	.277	.109	.300
10	1.192	.269	.163	.189	.300
11	1.122	.492	.589	.096	.300
12	.580	.450	.500	.490	.300
	.186	.191	.190	.154	.146

Table 15. Projection of future catch of pollock in Divisions 4VWX - 5.

$F_{0.1}$

YEAR	POP N	POP WT	SD	MATURE N	MATURE WT	SD	CATCH N	CATCH WT	SD	MATURE	F
1977	117054	198766.57	0	58076	143440.88	0	13899	35685.99	0		.3
1978	124445	210033.85	10119	60415	150615.41	233	11844	30000.00	0		.2471
1979	132829	228692.39	16014	65185	165919.17	3799	12015	30922.26	572		.2270
1980	133998	243223.24	16003	70634	183103.25	10856	13089	34198.51	2139		.2270
1981	132439	253597.20	17319	73354	197382.06	15935	10985	30000.00	0		.1841

F_{max} $F_{0.1}$

YEAR	POP N	POP WT	SD	MATURE N	MATURE WT	SD	CATCH N	CATCH WT	SD	MATURE	F
1977	117054	198766.57	0	58076	143440.88	0	13899	35685.99	0		.3
1978	124445	210033.85	10119	60415	150615.41	233	11844	30000.00	0		.2471
1979	132829	228692.39	16014	65185	165919.17	3799	19222	49143.68	952		.3860
1980	127557	221602.81	15636	64537	162026.21	10474	11938	30257.22	2059		.2270
1981	128221	235564.41	17012	69173	179426.15	15519	11383	30000.00	0		.2047

$F_{0.1}$ F_{max}

YEAR	POP N	POP WT	SD	MATURE N	MATURE WT	SD	CATCH N	CATCH WT	SD	MATURE	F
1977	117054	198766.57	0	58076	143440.88	0	13899	35685.99	0		.3
1978	124445	210033.85	10119	60415	150615.41	233	11844	30000.00	0		.2471
1979	132829	228692.39	16014	65185	165919.17	3799	12015	30922.26	572		.2270
1980	133998	243223.24	16003	70634	183103.25	10856	20931	54341.08	3438		.3860
1981	125438	229794.66	16083	66698	174136.16	14438	11299	30000.00	0		.2117

F_{max}

YEAR	POP N	POP WT	SD	MATURE N	MATURE WT	SD	CATCH N	CATCH WT	SD	MATURE	F
1977	117054	198766.57	0	58076	143440.88	0	13899	35685.99	0		.3
1978	124445	210033.85	10119	60415	150615.41	233	11844	30000.00	0		.2471
1979	132829	228692.39	16014	65185	165919.17	3799	19222	49143.68	952		.3860
1980	127557	221602.81	15636	64537	162026.21	10474	19107	48105.07	3304		.3860
1981	121819	214367.33	15841	63112	158777.67	14085	11712	30000.00	0		.2350

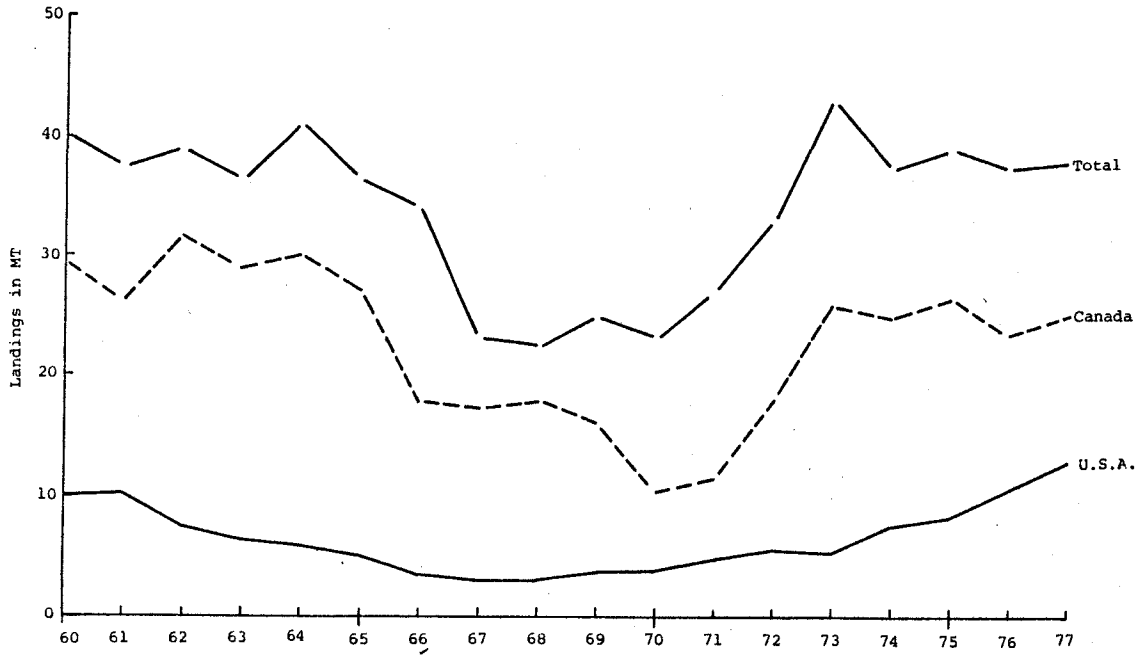


Figure 1. Pollock landings for Division 4VWX subarea 5 and statistical area 6 1960-77

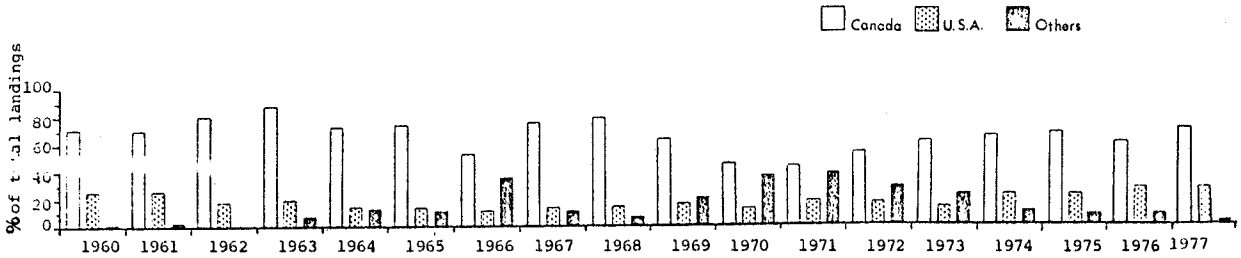


Fig. 2. Percentage of total landings of pollock for Canada, U.S.A., and other countries in Div. 4VWX, subarea 5, 1960-77.

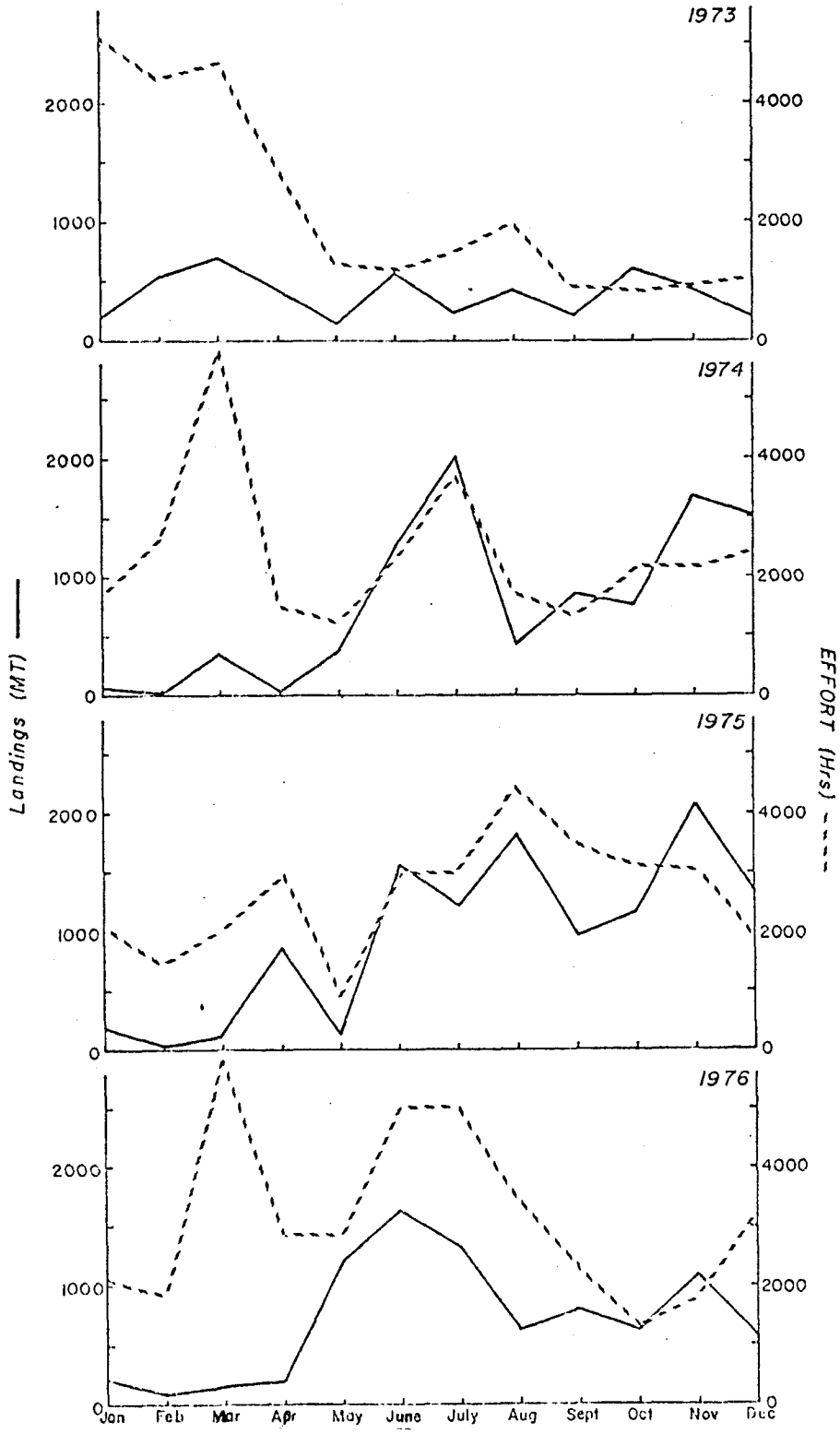
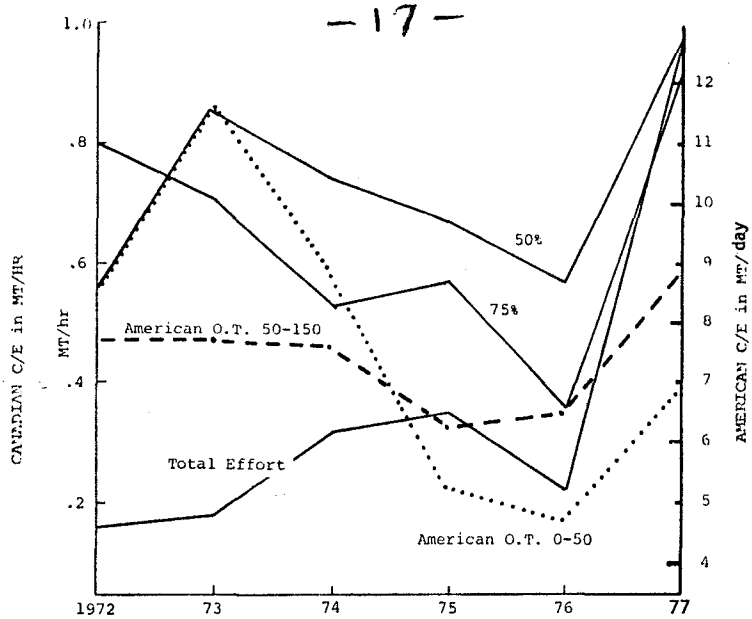


Figure 3. Landings of pollock (MT) and corresponding effort (hrs) for Canadian stern trawl of 501-900 gross tons in Div 4VXW - Subarea 5, 1973-76



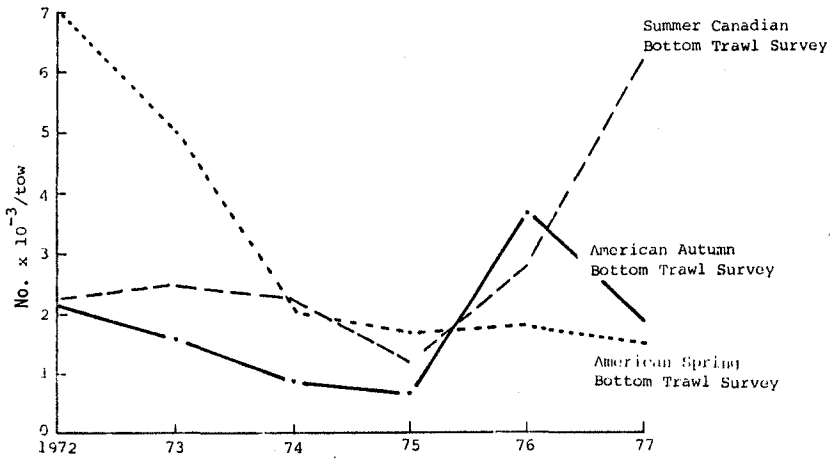
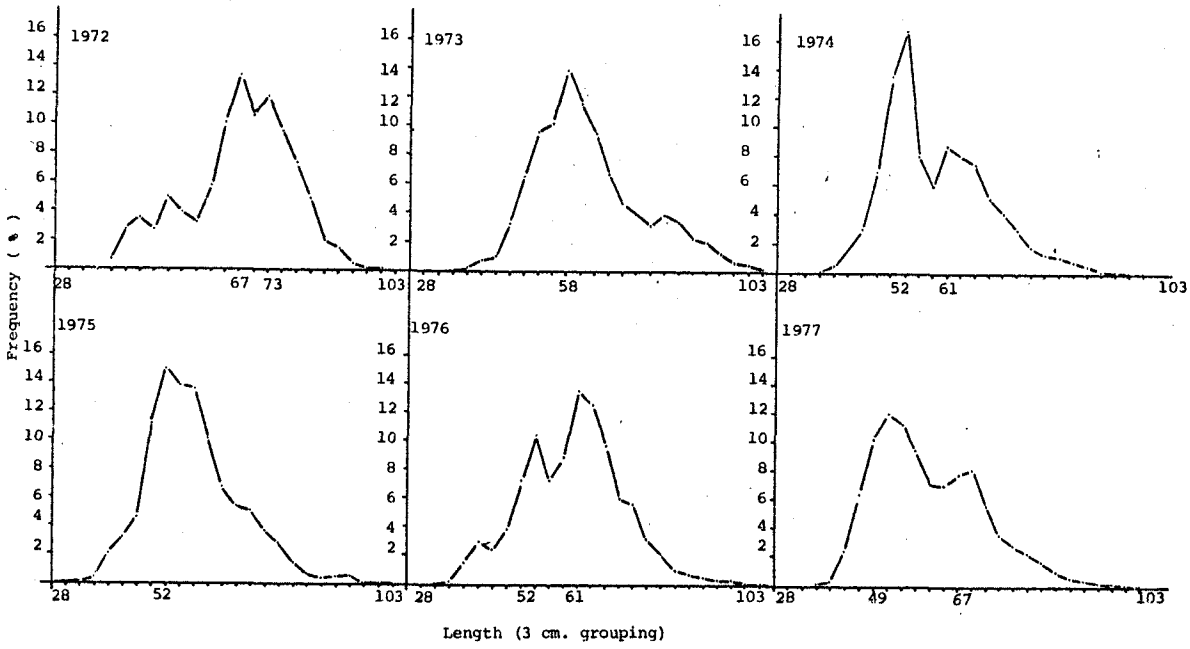


Fig. 4 Pollock Catch per unit of effort from commercial and research data in division 4VWX - 5

Figure 5. Length frequencies of Pollock in divisions 4VWX
Subarea 5 , 1972 - 1977



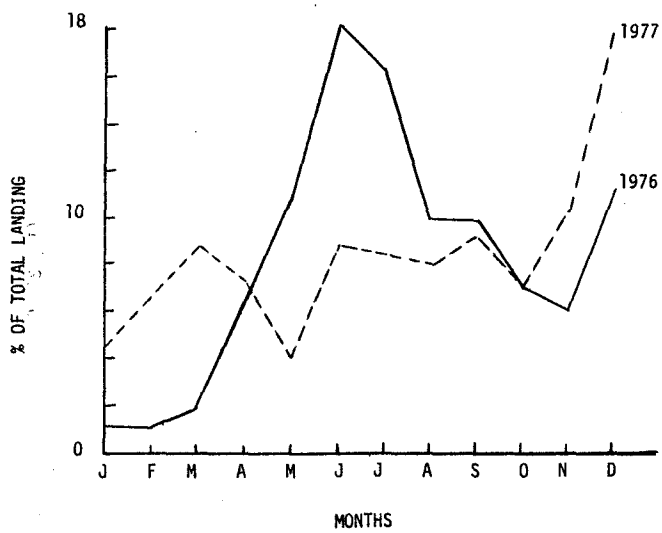
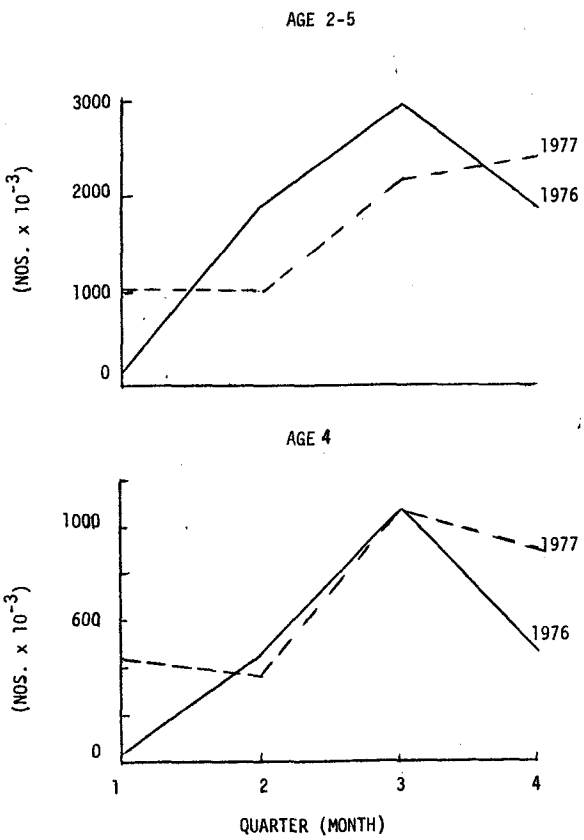


Fig. 6. Landings of pollock by month for Canadian (Maritime and Quebec) fishery for 1976 and 1977.

Fig. 7. Number of pollock in Canadian landings of 1976 and 1977.



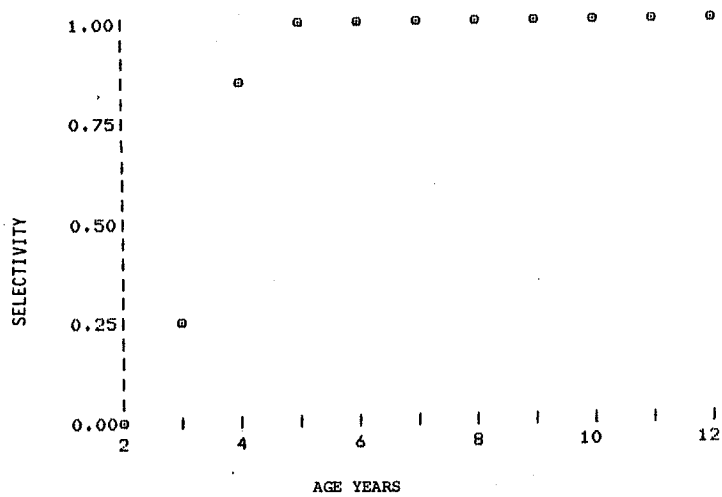


Figure 8. Partial recruitment curve used in cohort analysis, yield per recruit and projection.

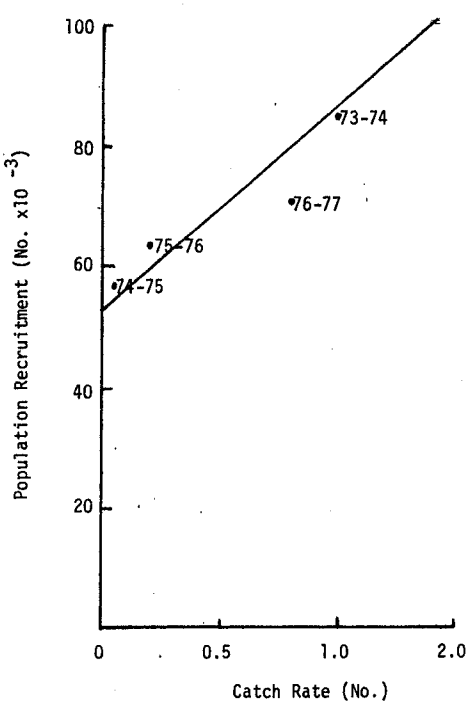


Fig. 9. GM Regression of recruitment (age 2 + 3) of pollock population and Canadian research cruise catch rate (age 2 + 3).

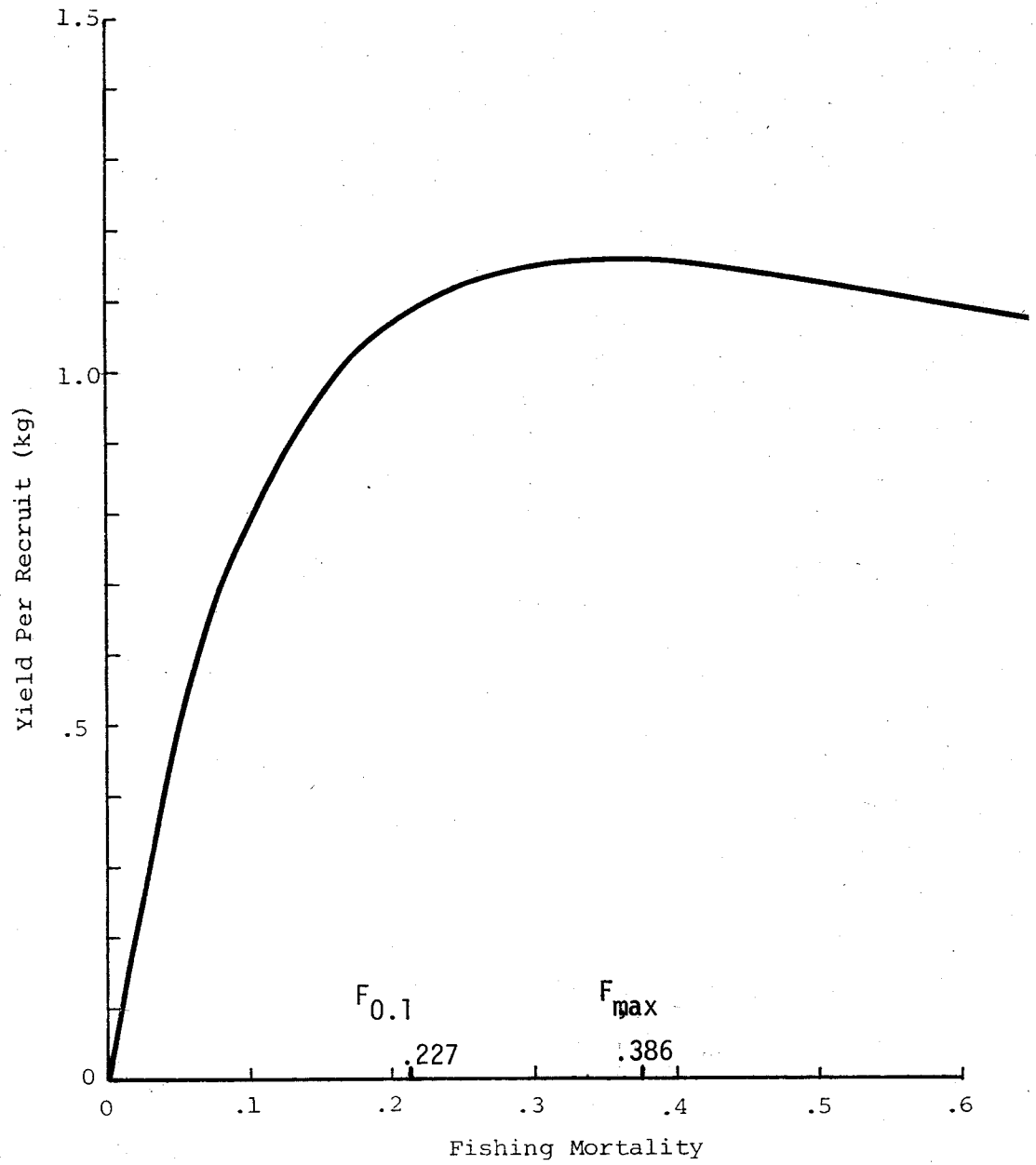


Fig. 10. Yield per recruit relationship for pollock in Division 4VWX-5.

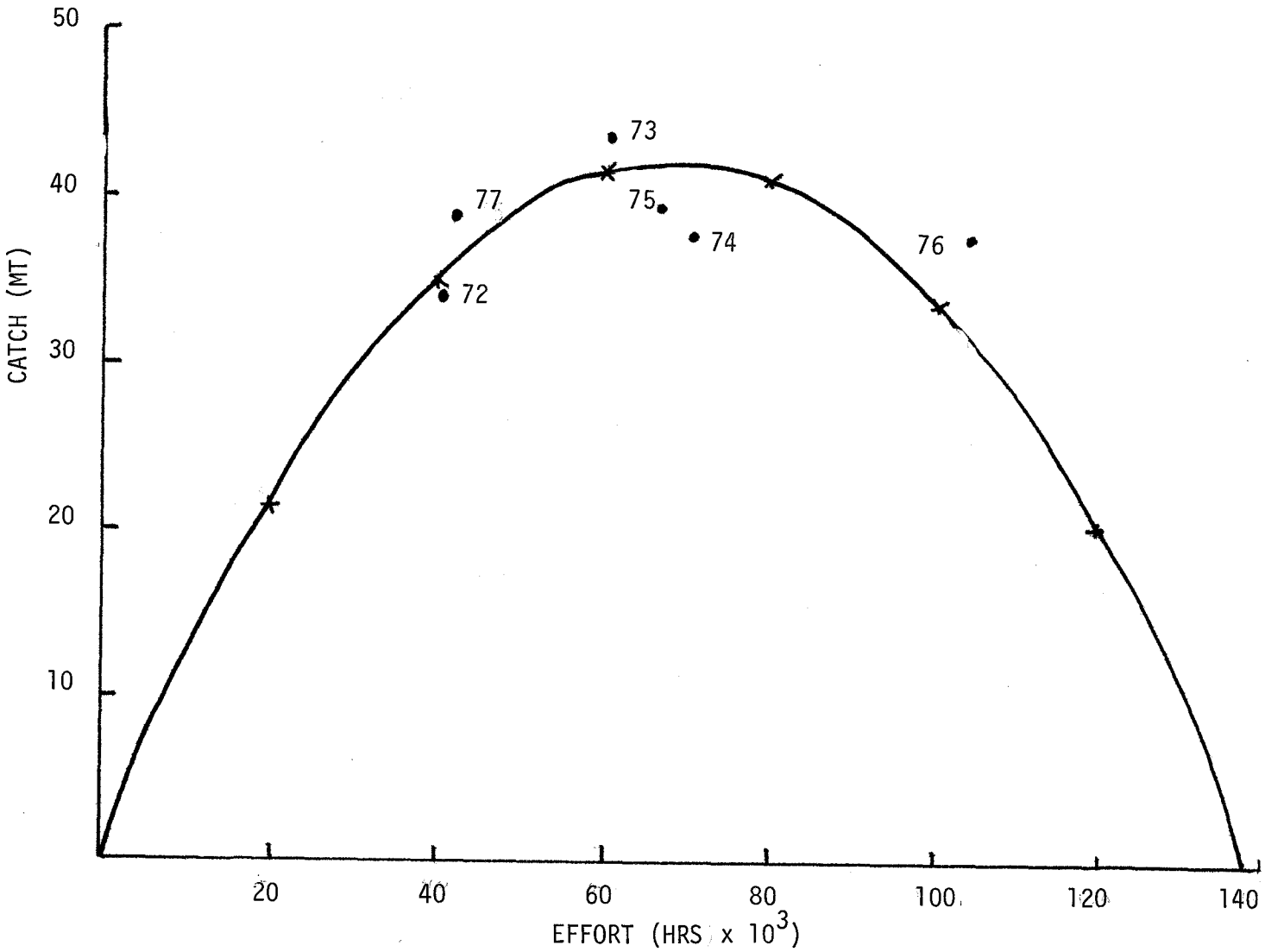


Fig. 11. Catch, effort and Shaeffer curve of pollock for Div. 4VWX + 5.

Table 16. Mean length at age for pollock in Div. 4VWS + 5, 1974-1977. (Length in cms)

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
(AGE 2)												
1977	-	34	35.5	31	-	-	-	37.69	42.25	41	39.25	42
1976	-	-	-	-	-	37.47	38.35	40.18	-	38.38	38.99	39.82
1975	-	-	-	34	-	36.1	←	41.28	→	41.67	40.9	40.36
1974	-	-	-	-	-	-	43	38	40.42	43.47	42.05	-
(AGE 3)												
1977	41.93	43.31	41.67	41.3	-	42	→	44	45.5	46.3	43.8	46
1976	44.25	45.43	52	43	52	49.2	49.65	50.88	49.17	49.22	48.2	48
1975	←	44.26	→	43.77	42	44.34	←	50.2	→	49.95	48.99	48.73
1974				45.29	46.6	48.75	49.11	47.94	49.33	51.2	50.89	53.26
(AGE 4)												
1977	49.6	50.44	49.27	50.3	-	50.85	→	51.95	53.09	55.8	51.92	53.38
1976	55.54	52.41	56.55	57.95	61.95	56.18	55.14	58.04	56.89	55.5	56.96	60.4
1975	←	53	→	51.96	52.68	54.29	←	56.31	→	57.36	55.73	56.54
1974	←	56.11	→	55.6	56.58	54.85	59.26	59.76	56.93	57.43	59.29	62.97
(AGE 5)												
1977	55	58.9	58.67	58.98		60.34		60.33	61.09	62.05	63	60.05
1976	61.17	59.96	61.82	63.45	63.49	63.41	62.79	63.56	62.19	61.76	65.07	67.38
1975	←	59	→	63.15	62.43	65.39	←	63.49	→	63.49	64.86	62.43
1974	←	64.53	→	63.62	63.19	63.81	65.64	65.36	66.89	65.38	-	69.44

Table 17. Population number and fishing mortality at age of pollock from cohort analysis

AGE	1973	1974	1975	1976	1977
			POPULATION NUMBERS		
2	44,880	21,391	20,125	17,013	12,909
3	16,811	35,788	16,934	16,192	13,546
4	17,336	12,133	22,178	10,606	10,259
5	8,970	9,228	6,835	10,349	5,062
6	2,506	3,425	4,772	4,109	4,714
7	1,719	1,084	1,616	2,545	2,341
8	1,555	639	483	756	1,151
9	1,053	959	261	223	370
10	720	421	687	136	146
11	141	179	263	457	77
12	40	38	90	120	330
	95,732	85,284	74,253	62,505	50,907
			FISHING MORTALITY		
2	.026	.033	.017	.028	.013
3	.126	.279	.268	.256	.200
4	.431	.374	.562	.540	.600
5	.763	.459	.309	.586	.800
6	.638	.551	.429	.362	.800
7	.790	.608	.560	.594	.800
8	.283	.693	.574	.515	.800
9	.716	.134	.452	.221	.800
10	1.192	.269	.207	.369	.800
11	1.122	.492	.589	.126	.800
12	.580	.450	.500	.490	.800
	.238	.267	.312	.320	.401

Table 18. Projection of Future Catch of Pollock in Divisions 4VWX-5.

Revision to Res. Doc. 78/24 ADDENDUM 1

Fully Recruited F = .3 $F_{0.1}$ = .227

YEAR	POP N	POP WT	SD	MATURE N	MATURE WT	SD	CATCH N	CATCH WT	SD	MATURE F
1977	117054	198767.03	0	58076	143431.26	0	13899	35682.85	0	.3
1978	130869	215161.86	12697	60563	150727.45	292	11859	30000.00	0	.2469
1979	135541	231993.47	16460	66993	167763.20	4627	12287	31199.61	696	.2270
1980	136151	247565.38	18697	73054	187258.26	11728	13627	35093.49	2384	.2270
1981	134579	258309.18	17636	74851	201724.80	16942	13924	37712.25	3396	.2270
1982	133062	264202.42	18334	74058	208672.72	17882	13744	38933.53	3440	.2270
1983	134041	268148.07	23105	73000	211125.94	16269	13530	39353.53	3007	.2270
1984	132803	267763.58	29397	72693	211243.37	17175	13453	39352.37	3160	.2270
1985	138846	273778.01	29311	72861	212589.06	22962	13522	39652.05	4359	.2270
1986	138222	273778.63	27361	74197	213572.44	26727	13687	39743.02	5146	.2270

Fully recruited F = .8 $F_{0.1}$ = .233

YEAR	POP N	POP WT	SD	MATURE N	MATURE WT	SD	CATCH N	CATCH WT	SD	MATURE F
1977	50905	91014.54	0	27158	68287.18	0	13899	35682.85	0	0.8
1978	67952	88792.06	13963	21125	48344.32	321	12551	30000.00	0	1.2286
1979	74609	85200.27	18051	23037	38451.46	5162	3836	6765.91	754	.2330
1980	84536	110946.09	20617	36791	65231.98	12902	6525	11913.94	2393	.2330
1981	89182	134200.20	19872	45151	92289.51	18957	8210	17206.08	3623	.2330
1982	91597	153099.70	20246	48509	112463.14	20196	8852	21024.67	3919	.2330
1983	95577	169850.00	24730	50074	127457.42	18149	9137	23838.08	3458	.2330
1984	96371	180691.16	30773	51647	138637.54	18417	9401	25913.22	3383	.2330
1985	103378	193434.69	30459	53020	146867.53	24012	9680	27489.22	4446	.2330
1986	103437	199000.78	28185	55181	153560.65	27720	10016	28687.59	5303	.2330