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Canadian Atlantic Fisheries Scientific Advisory Committee

CAFSAC Research Document 84/77

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Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 84/77

Assessment of pollock (Pollachius virens) in Divisions 4VWX and SA5

by

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Abstract

Commercial landings and catch rates decreased in 1983 from the high levels in 1978-1982. The catch in 1983 was substantially less than the TAC. Canadian and U.S.A. research surveys however indicate that recruitment prospects are good, as the 1979 and 1982 year-classes appear to be the largest in the observed time series. It is concluded, from cohort analyses, that a terminal instantaneous fishing mortality of 0.2 in 1983 is applicable: this result is based on the relationship, exploitable biomass, and ages 5 biomass. The projections show that the $F_{0.1}$ catch in 1985 will be 50,000 t if the TAC is taken in 1984, or 49,000 t if the $F_{0.1}$ catch is taken in 1984.

Résumé

Les débarquements et les taux de prises commerciaux ont décru en 1983, par rapport aux niveaux élevés observés de 1978 à 1982. Les captures de 1983 se sont situées passablement au-dessous du TPA. Des études canadiennes et américaines indiquent toutefois que les perspectives du recrutement sont bonnes, car les classes d'âge de 1979 et 1982 semblent être les plus importantes de la série des temps observés. On en vient à la conclusion, à la suite d'analyses des cohortes, qu'il faut situer le taux de mortalité instantanée par pêche à 0,2 à la fin de 1983; ce résultat est basé sur le rapport, la biomasse exploitable et d'âge 5 et plus. Les projections indiquent que les captures à $F_{0,1}$ en 1985 seront de 50 000 t si le TPA est pris en 1984, ou de 49 000 t si les captures à $F_{0,1}$ sont réalisées en 1984.

Introduction

The TAC in 1983 was set at 45,000 t; the catch (41,000 t) was therefore less than the TAC, and the lowest since 1977.

Trends in Reported Landings

In the mid-1960s catches began to decline and reached a minimum in 1968 (Table 1, Figure 1). They increased again throughout the 1970s to 1981, then declined in 1982 and 1983. Recent catches and TACs ('000 t) have been as follows:

	1975	1976	1977	1978	1979	1980	1981	1982	1983
TAC	55	55	30	30	30	40	54	55	45
Nominal Catch	39	38	38	45	47	55	58	52	41

Distribution of Catch

The major portion of the catch is usually taken from June to December, in Divisions 4W, 4X, 5Y and 5Ze (Tables 2 and 3). However, in 1983 there were substantial decreases in all these areas. The vessel and gear categories which showed the most decrease in 1983 were the large otter trawlers (Tonnage Class 5) in Division 4W and Subarea 5, and the longliners in Division 4X (Table 4).

Age Composition of Landings

The age composition of landings in 1983 was calculated using 106 samples, which were aggregated into 40 categories (Table 5). Seasonal values for the von Bertalanffy parameters a and b were obtained from Canadian research vessel surveys, and applied to the corresponding categories. The Canadian proportions-at-age for Subarea 5 otter trawlers, and Division 4X longliners and gillnetters were used to prorate the U.S.A. catches, whilst the catch-at-age for other foreign catches (viz. for the U.S.S.R., Cuba, Japan and Portugal) were obtained via length frequencies from the International Observer Program.

The Canadian catch-at-age and total catch-at-age in numbers, and the percent composition of ages in the total catch are provided (Tables 6-8); these show quite clearly the dominance of the 1979 year-class in 1982 and 1983, and the poor 1981 year-class. The weights-at-age in the commercial catch are given (Table 9), plus the nominal catch-at-age in tonnage and percentage of the nominal catch weight by age (Tables 10 and 11). The average weight and age of fish in the catch (Figure 2) show a decrease in 1983 from 1982.

Comparison of the observed proportions at age by weight in the commercial catch and that projected in the 1983 assessment of this stock (McGlade et al. 1983) shows a higher proportion of age 4 fish (Figure 3), which infers that the 1979 year-class is larger than expected.

Abundance Indices

The Canadian summer RV survey series is carried out throughout the Scotian Shelf and Bay of Fundy (Figure 4) (Halliday and Koeller 1981), but has previously only been used to indicate relative strengths of incoming year-classes of pollock, rather than providing abundance indices with which to calibrate cohort analysis. In 1981, the 12 year A.T. Cameron series terminated, and in 1982 the survey was carried out by the Lady Hammond: from comparative fishing experiments a conversion factor of 1.0 between these vessels was derived for pollock. In 1983 the Alfred Needler was used, but a conversion factor for these latter two vessels has not been derived as yet for pollock. Thus the estimates provided remain unconverted (Tables 12, 13, and 14). Results from the full series of surveys carried out by the Lady Hammond since 1979 are also included (Table 12).

The U.S.A. have carried out offshore surveys (Figure 5) in the spring, summer and autumn, although in certain years the spring and summer surveys were not undertaken, or contained no catches of pollock (Tables 15 and 16). Inshore surveys (Figure 6) have also been conducted in the spring and summer since 1977 and 1978, respectively (Table 17).

All the research vessel catch rates, in numbers-at-age per standard tow (viz. Tables 12, 13, 16, and 17) indicate that the 1979 year-class is exceptionally strong, although its appearance throughout any single series is not consistently high. The 1971 year-class has been the strongest and most persistent in the U.S.A. spring and autumn surveys, although in more recent years the 1975, 1976 and potentially the 1982 year-classes have also appeared to be relatively strong (Mayo and Clark 1984).

Trends in overall catch rates (number per standard tow) for Canadian and U.S.A. research vessel surveys show parallel movements within the time series with a decrease in 1983 from 1982 (Table 18, Figure 7).

Catch rates by Canada-Maritimes otter trawlers (Table 19) all show a decline in 1983. In the previous assessment (McGlade et al. 1983), it was discovered that several entries existed in the Regional Statistical records where pollock represented more than 50% of the catch but was not listed as the main species. For comparative purposes the catch rate series for January-June with pollock listed as the main species, and that used in McGlade et al. (1983) are both included. The catch rate in 1983, in fact, declined to a level similar to that in the period between 1978 and 1979, when the total Canadian catch was very similar.

In summary, then, both research vessel and commercial catch rate indices show a decrease in 1983 compared to 1982.

Estimation of Total Mortality

Estimates of total mortality, Z, from the Canadian research vessel summer survey series showed an average for the period 1974-1983, of 0.5 for fish of ages 4-12 and 0.66 for fish of ages 5-12. With a constant natural mortality of 0.2, the fishing mortality for the period would lie between 0.3 and 0.46.

Total mortality estimates based on commercial data were derived from Canadian fishing effort (Table 20) and the numbers-at-age in the nominal catch (Table 21). The values in 1983 all appear anomalously large, especially when compared to those in the preceding years of each series; as such they provide no useful indication of the fishing mortality in 1983.

Estimation of Stock Abundance

As a result of a preliminary series of runs, designed to indicate the most useful catch rate index with which to calibrate the cohort (SPA) analysis, the following 3 relationships were selected:

(a)	SPA mid-year biomass of fish of ages 5 - 11	vs	commercial catch rate OTB-1,2 (TC5) (all catches pollock 50% of total) January-June
(b)	SPA mid-year exploitable biomass (using the selectivity pattern of each year)	vs	commercial catch rate (as above)
(c)	SPA mid-year exploitable biomass (using the average selectivity pattern for the period 1974-1982 for each year)	vs	commercial catch rate (as above)

All calculations were performed using Pope's (1972) cohort formula (Rivard 1982). Natural mortality was assumed to be 0.2 on ages 2-11. Assuming full recruitment at age 5, the partial recruitment of fish of ages 2-4 was estimated as the F-at-age divided by the fully recruited F. Initial runs were made using the partial recruitment vector derived in McGlade et al. (1983), which was 0.04, 0.62, 0.86, 1.0 ... 1.0 on fish of ages 2-11: the partial recruitment vector was then altered to match the average selectivity pattern for the period 1974-1982, of 0.041, 0.375, 0.80 on fish of ages 2 to 4. The cohort analyses were calibrated using mid-year estimates of biomass from SPA as described above versus the commercial catch rate: for (b) and (c) the selectivity matrix from each run was used to calculate the SPA mid-year exploitable biomass, using (i) the annual selectivity patterns and (ii) the average pattern for 1974-1982. A series of terminal fishing mortalities ranging from 0.15-0.35 were examined (Table 22). The calibration was based on the intercept and slope statistics from a least squares regression for the relationships given above, plus the correlation coefficient for the two vectors. The best relationship for a combination of these criteria, resulted from the run with a terminal fishing mortality of 0.2 (Table 23, Figure 9). These results also indicate that the effort in 1983, was similar to the level in 1978 and 1979 when the fishing mortalities were 0.4 and 0.3, respectively. Such a change in the fishing mortality and effort relationship may however, have resulted from the contribution made by the anomalously large catch of the 1979 year-class, at an age which is not considered as fully recruited.

Yield-Per-Recruit

A Thompson and Bell yield-per-recruit analysis (Rivard 1982) using the available 1983 weights-at-age for ages 2-11 gave an $F_{0.1}$ value of 0.28. This is the same as observed in the previous assessment.

Projections

Two projections (Rivard 1982) were made using the input parameters shown in Table 24. The output is shown in Tables 25a and b. If the TAC is taken in 1984, fishing at $F_{0.1}$ in 1985 would yield a catch of 50,000 t. If the $F_{0.1}$ catch (57,000 t) is taken in 1984 then fishing at $F_{0.1}$ would yield a catch of 49,000 t in 1985.

Conclusions

The rapid increase in catches since 1978, which resulted in a peak in 1981 of 59,000 t, dropped to 41,000 t in 1983. Recruitment, however, appears to be good. Moreover the catches in 1984 and 1985 are likely to be dominated by the 1979 year-class which currently represents the strongest year-class in the time series.

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Table 1. Pollock Landings (t, round fresh) by Country for Divisions 4VWX and Subareas 5 and 6, 1960 - 1983.

Year	Canada	Fed. Rep. Germany	German Dem. Rep.	Japan	Spain	USSR	United Kingdom	U.S.A.	Other	Total
1960	29470	-	-	-	763	-	-	10132	1	40366
1961	26323	-	-	-	982	-	-	10265	1	37571
1962	31721	-	-	-	-	-	-	7391	-	39112
1963	28999	126	-	-	-	906	28	6653	-	36712
1964	30007	208	-	-	-	4603	374	6006	55	41253
1965	27316	71	-	-	1361	2667	11	5303	-	36729
1966	18271	-	-	-	2384	9865	12	3791	-	34323
1967	17567	-	9	-	1779	644	1	3312	-	23312
1968	18062	-	-	-	1128	372	-	3280	7	22849
1969	15968	1188	2195	-	1515	227	-	3943	7	25043
1970	10753	3233	4710	40	532	527	-	3976	-	23771
1971	11757	633	6849	15	912	2216	-	4890	3	27275
1972	18022	475	4816	8	616	3495	4	5729	54	33219
1973	26990	1124	948	1570	3113	3092	-	6303	36	43176
1974	24975	149	2	40	1500	2348	48	8726	14	37802
1975	26548	236	96	-	709	2004	-	9318	124	39035
1976	23568	994	24	-	303	1466	-	10861	390	37606
1977	24653	368	-	1	2	268	-	13056	53	38401
1978	26801	-	-	110	-	502	-	17714	180	45307
1979	29967	7	-	19	-	1025	-	15541	72	46631
1980	35986	-	-	81	-	950	-	18280	131	55428
1981	40270	-	-	15	-	358	-	18171	90	58904
1982*	38029	-	-	3	-	297	-	14885	128	53342
1983*	26370	-	-	6	-	329	-	13841	328	40874

* Provisional

Table 2. Pollock landings (t, round fresh) by month and country for NAFO Divisions 4VWX - 5 - 6.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total (plus NK)
						CANADA (Maritimes and Newfoundland)							
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	1062	1748	2271	1859	1006	2202	2097	2003	2304	1333	2309	4459	24653
1978	2511	3265	1864	2070	3425	2772	2755	1228	1262	839	706	4101	26801
1979	935	1536	1523	1970	2597	4664	4850	3389	1866	1645	1486	3506	29967
1980	1465	3037	2441	1903	3511	5501	5382	3095	2220	3617	2014	1800	35986
1981	2562	1811	3421	2054	1193	2363	2671	3380	4632	2462	4831	8890	40270
1982*	2745	1010	1296	1075	2480	5043	5876	5360	3913	3122	2389	3720	38029
1983*	1817	1249	1210	2184	4786	5905	3798	2497	1522	687	465	250	26370
						U.S.A.							
1972	455	318	228	229	200	394	329	294	314	488	1082	1397	5729
1973	419	313	311	406	331	418	335	302	262	573	1111	1519	6303
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	9318
1976	706	658	501	665	936	1035	985	800	1125	669	813	1305	10861
1977	1017	661	460	817	1061	1038	1350	1149	933	924	1188	1709	13056
1978	884	1065	1035	1394	1150	1347	988	1593	925	1251	2665	2620	17714
1979	1196	434	505	753	1298	1332	1252	1706	1392	1352	1876	1605	15541
1980	1001	1093	705	977	1534	1437	1603	1536	1501	1285	1961	2276	18280
1981	1851	1093	946	1230	1444	1300	1127	1044	820	1645	2661	2738	18171
1982*	822	769	914	775	867	903	1289	1062	----------	5767	----------		14885
1983*	1044	746	681	651	1111	1847	1494	1307	879	1033	1556	1492	13841
						OTHERS							
1972	599	481	440	686	538	627	867	270	183	47	385	4278	9468
1973	513	1808	442	966	48	812	117	367	700	407	1996	1689	9883
1974	42	567	165	132	751	235	612	463	412	228	176	268	4101
1975	154	382	311	129	645	339	234	51	195	156	327	245	3169
1976	33	129	273	312	228	265	257	275	659	543	113	89	3177
1977	-	2	84	43	398	96	11	17	5	8	2	-	692
1978	-	-	-	9	109	172	152	105	7	92	2	8	792
1979	-	19	3	10	705	226	101	4	48	3	4	-	1123
1980	5	53	12	153	549	264	47	14	9	27	29	-	1162
1981	26	38	24	49	114	108	80	14	8	2	-	-	463
1982*	10	8	5	12	272	87	32	1	1	-	-	-	428
1983*	-	-	-	20	438	179	12	6	-	-	-	8	663

* Provisional

Table 3. Pollock landings (t, round fresh) for Divisions 4VWX, Subarea 5, and Statistical Area 6, 1960-83.

Year	4V	4W	4X	Total 4VWX	5Y	5Ze	5Zw	Total 5Z	5NK	Total SA 5	SA 6	Total
1960	1502	8354	20132	29988	6545	-	-	3834	18	10397	-	40385
1961	1864	13167	14321	29352	5017	-	-	3177	25	8219	-	37571
1962	1292	12045	19624	32961	2560	-	-	3576	15	6151	-	39112
1963	674	9152	20645	30471	2168	-	-	3947	10	6125	116	36712
1964	474	12488	19283	32245	1754	-	-	7250	-	9004	4	41253
1965	1205	13134	13390	27729	1933	-	-	7065	-	8998	2	36729
1966	788	11040	12648	24476	953	-	-	8846	-	9799	48	34323
1967	657	5836	8290	14783	1728	-	-	6790	14	8532	2	23319
1968	1013	5954	10656	17623	1416	3724	82	3806	-	5222	4	22849
1969	300	3938	10983	15221	4635	5025	162	5187	-	9822	-	25043
1970	649	2952	8194	11795	6281	5157	123	5280	-	11561	415	23771
1971	531	1802	9739	12072	7016	7096	142	7238	58	14312	891	27275
1972	597	3419	16190	20206	6419	6519	51	6570	-	12989	24	33219
1973	1004	5871	23225	30100	5202	6235	1618	7853	-	13055	21	43176
1974	307	4740	20362	25409	6106	6233	5	6238	-	12344	49	37802
1975	799	5697	18668	25164	6015	7848	3	7851	-	13866	5	39035
1976	1102	3424	19700	24226	6441	6915	11	6926	12	13379	3	37608
1977	1347	6082	14700	22129	8278	7846	79	7925	36	16239	34	38402
1978	2931	4910	15161	23002	12238	9943	17	9960	91	22289	16	45307
1979	4877	4963	18340	28180	9856	8356	11	8367	221	18444	7	46631
1980	3893	7511	20485	31889	11388	11883	20	11900	245	23536	3	55428
1981	2316	15678	18842	36836	12475	9298	21	9319	247	22041	27	58904
1982*	2939	9373	21036	33348	10074	9903	17	9920	-	19994	-	53342
1983*	5570	4787	13201	23558	9098	-	-	8218	-	17316	-	40874

* Provisional

Table 4. Distribution of Canada-Maritimes pollock landings (t, round fresh) by area, quarter, and gear for 1982 and 1983. (OTB-1,2 = stern and side otter trawl; GN = Gillnet; LL = longline).

			Jan - Mar		Apr - June		July - Sept		Oct - Dec		Total for Area	
			1982	1983	1982	1983	1982	1983	1982	1983	1982	1983
4V	OTB-1,2	TC 6	-	-	-	5	56	-	11	-		
		5	206	38	317	2675	1282	1648	184	101		
		4	137	42	120	173	93	574	78	35		
		3	2	-	-	6	-	1	3	4		
	LL		-	-	-	2	-	5	4	3		
	GN		-	-	2	-	33	-	1	-	2529	5312
4W	OTB-1,2	TC 6	-	-	-	-	72	-	155	-		
		5	1844	597	662	1762	642	362	3198	170		
		4	185	4	135	490	125	29	238	177		
		3	28	26	60	86	8	1	-	-		
		1,2	1	-	47	64	165	67	55	7		
	LL		2	3	10	5	29	15	23	8		
	GN		45	41	176	65	822	308	239	101	8966	4388
4X	OTB-1,2	TC 6	-	-	105	-	51	-	63	-		
		5	595	1637	1943	640	458	272	818	149		
		4	88	142	67	218	370	215	179	21		
		3	359	404	1721	3742	2188	1361	257	112		
		1,2	162	253	729	1020	966	795	192	113		
	LL		30	3	522	42	4033	53	648	15		
	GN		309	46	1481	378	1813	671	368	175	20515	12477
5Y	OTB-1,2	TC 4	-	-	-	14	-	10	2	-		
		3	-	7	7	100	407	354	162	99		
		1,2	-	-	3	11	31	103	6	9		
	LL		-	-	5	-	20	1	8	-		
	GN		-	-	51	-	219	6	6	-	927	714
5Z	OTB-1,2	TC 6	-	-	4	-	23	-	288	-		
		5	874	999	1	647	775	766	1879	52		
		4	-	3	250	107	47	17	58	-		
		3	-	-	31	408	82	73	1	2		
		1,2	-	-	2	85	34	34	9	-		
	LL		-	-	5	14	59	25	7	5		
	GN		-	-	-	10	-	47	-	-	4430	3294

Table 5. 1983 Canadian commercial samples for pollock Divs. 4VWX and SA 5. Number of fish measured (fish aged). OTB-1 = side trawl; OTB-2 = stern trawl; GN = gillnet; LHP = handlines.

Area	Gear	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
4V	OTB-1	-	-	-	-	-	-	-	(15) 336	-	-	-	-
	OTB-2	-	-	(32) 240	-	(79) 931	(108) 1079	(41) 506	(70) 777	(31) 200	-	-	-
4W	OTB-1	-	-	-	-	-	(37) 151	-	-	-	-	-	-
	OTB-2	(91) 566	-	(24) 159	(154) 1003	(72) 474	-	-	-	-	-	(27) 460	
	GN	-	-	-	-	-	-	(25) 178	-	(24) 99	-	-	-
4X	OTB-1	-	-	-	(38) 210	-	-	-	(41) 321	-	-	(43) 356	-
	OTB-2	(42) 135	(164) 1068	(76) 663	(125) 908	(257) 2125	(132) 1190	(50) 325	(96) 752	(27) 184	(39) 215	-	(21) 201
	GN	-	-	-	(32) 207	(38) 242	(36) 265	(39) 176	(67) 528	-	-	-	-
	LHP	-	-	-	-	-	-	(42) 243	(37) 230	-	-	-	-
5Z	OTB-1	-	-	-	-	-	(23) 258	-	-	-	-	-	-
	OTB-2	(78) 588	-	-	-	-	(93) 775	-	(87) 941	-	-	-	-

Table 6. Canadian catch-at-age for pollock Divs. 4VWX and SA 5 (No. x 10^{-3}).

	YEAR									
Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	303	231	392	150	104	31	176	1585	197	17
3	4417	2290	2149	2233	2297	2269	1278	973	4822	1277
4	1808	5832	2554	3029	4136	4575	3016	2330	1872	8884
5	2425	1570	3240	1750	3016	2883	4815	4569	416	917
6	1147	1397	860	2111	1193	1823	2531	2660	1661	128
7	397	432	638	775	1135	474	661	1065	1824	303
8	318	96	155	348	311	163	161	259	988	484
9	84	34	18	75	96	77	91	261	545	230
10	92	42	25	21	18	27	21	73	211	76
11	89	30	17	24	27	13	11	19	108	23

Table 7. Total catch-at-age for pollock Divs. 4VWX and SA 5 (No. x 10^{-3}).

	YEAR									
Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	617	372	514	170	196	234	368	2180	302	18
3	7281	3346	2952	2526	3023	3628	1694	2419	5984	1351
4	2889	8434	3583	3972	4686	6349	4971	2975	2566	9996
5	3625	1890	4452	2431	3665	3922	6370	6424	711	1350
6	1327	1655	1233	2937	1824	2323	3495	3422	2428	238
7	512	555	961	1101	2071	717	1203	1437	2200	584
8	414	133	259	609	660	448	356	517	1286	863
9	112	55	29	174	366	191	259	359	726	333
10	124	70	32	83	152	74	99	196	306	147
11	103	47	34	44	111	38	47	52	203	38

Table 8. Percent total catch-at-age for pollock Divs. 4VWX and SA 5 (%).

	YEAR									
Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	4	2	4	1	1	1	2	11	2	0
3	43	20	21	18	18	20	9	12	36	9
4	17	51	26	28	28	35	26	15	15	67
5	21	11	32	17	22	22	34	32	4	9
6	8	10	9	21	11	13	19	17	15	2
7	3	3	7	8	12	4	6	7	13	4
8	2	1	2	4	4	2	2	3	8	6
9	1	0	0	1	2	1	1	2	4	2
10	1	0	0	1	1	0	1	1	2	1
11	1	0	0	0	1	0	0	0	1	0

Table 9. Weights-at-age in the commercial catch for pollock in Divs. 4VWX and SA 5.

	YEAR									
Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	0.81	0.89	0.81	0.93	0.86	0.91	1.22	1.03	0.91	0.57
3	1.44	1.47	1.55	1.10	1.07	1.39	1.87	1.77	1.60	1.17
4	2.18	2.10	2.20	1.55	1.57	1.95	2.27	2.53	2.50	1.73
5	3.07	2.97	2.97	2.45	2.64	2.86	3.07	2.87	3.30	3.03
6	4.10	3.95	3.76	3.35	3.65	3.72	3.34	3.50	3.84	4.12
7	5.10	5.00	4.51	4.34	4.86	4.46	4.14	4.31	4.10	4.51
8	6.11	6.24	5.18	5.63	5.44	6.33	5.92	5.51	5.10	4.96
9	6.68	7.07	6.14	6.38	6.52	6.00	6.24	6.51	6.10	5.38
10	7.27	7.29	7.64	7.22	7.08	7.34	7.87	7.78	7.13	6.46
11	8.01	7.83	7.66	8.32	9.97	8.04	8.48	8.21	7.72	7.95

Table 10. Nominal catch-at-age (t) for pollock in Divs. 4VWX and SA 5.

	YEAR									
Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	500	331	416	344	169	213	449	2245	275	11
3	9465	4919	4576	3879	3235	5043	3168	4282	9574	1756
4	5778	17711	7883	6157	7357	12381	11284	7527	6415	22291
5	9969	5613	13222	8406	9676	11217	19556	18437	2346	4617
6	4836	6537	4636	9839	6658	8642	11673	11977	9324	995
7	2478	2775	4334	4778	10065	3198	4980	6193	9020	2686
8	2430	861	1342	3429	3590	2836	2108	2849	6559	4496
9	710	389	178	1110	2386	1146	1616	2337	4429	2005
10	889	510	244	599	1076	543	779	1525	2182	1033
11	813	368	260	366	1107	306	399	427	1567	308

Table 11. Percentage of nominal catch weight by age (%) for pollock in Divs. 4VWX and SA 5.

	YEAR									
Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	1	1	1	1	0	0	1	4	1	0
3	25	12	12	10	7	11	6	7	19	4
4	15	44	21	16	16	27	20	13	12	55
5	26	14	36	22	21	25	35	32	5	11
6	13	16	12	25	15	19	21	21	18	2
7	7	7	12	12	22	7	9	11	17	7
8	6	2	4	9	8	6	4	5	13	11
9	2	1	0	3	5	3	3	4	9	5
10	2	1	1	2	2	1	1	3	4	3
11	2	1	1	1	2	1	1	1	3	1

Table 12. Stratified mean numbers-per-standard-tow for pollock in Canadian summer and fall bottom trawl surveys (Strata 43-95).

Year	AGES 1	2	3	4	5	6	7	8	9	10	11	12	12+	UK	4+	5+	6+
A.T. CAMERON (summer)																	
1970	0.008	1.916	0.471	0.287	0.210	0.205	0.171	0.103	0.040	0.000	0.046	0.012	0.000	0.008	1.082	0.795	0.585
1971	0.000	0.775	0.578	0.177	0.043	0.020	0.034	0.012	0.008	0.024	0.000	0.000	0.000	0.000	0.318	0.141	0.098
1972	0.012	0.103	0.203	1.335	0.397	0.123	0.036	0.064	0.055	0.028	0.012	0.008	0.020	0.012	2.090	0.755	0.358
1973	0.000	0.428	0.399	1.237	0.433	0.060	0.024	0.044	0.055	0.004	0.028	0.012	0.000	0.000	1.897	0.660	0.227
1974	0.008	0.044	1.010	0.253	0.332	0.180	0.204	0.118	0.090	0.056	0.134	0.048	0.000	0.000	1.415	1.162	0.830
1975	0.000	0.008	0.019	0.351	0.299	0.393	0.066	0.098	0.031	0.004	0.008	0.000	0.000	0.000	1.250	0.899	0.600
1976	0.000	0.035	0.214	0.612	1.077	0.260	0.428	0.155	0.044	0.048	0.020	0.020	0.028	0.008	2.900	2.088	1.011
1977	0.000	0.278	0.836	1.056	2.176	1.528	0.216	0.383	0.129	0.068	0.036	0.016	0.000	0.004	5.612	4.556	2.380
1978	0.000	0.004	0.184	0.673	0.990	0.365	0.333	0.104	0.046	0.002	0.000	0.016	0.120	0.041	2.690	2.017	1.027
1979	0.000	0.000	0.118	0.709	0.819	0.608	0.250	0.163	0.012	0.040	0.000	0.000	0.000	0.046	2.647	1.938	1.119
1980	0.011	0.610	0.723	2.056	3.648	1.266	0.764	0.289	0.111	0.066	0.000	0.000	0.000	0.006	8.206	6.150	2.502
1981	0.007	0.167	0.188	0.062	0.587	0.413	0.270	0.234	0.075	0.073	0.027	0.000	0.001	0.043	1.785	1.723	1.136
LADY HAMMOND (summer)																	
1982	0.000	0.258	2.919	0.285	0.119	0.362	0.319	0.160	0.128	0.076	0.022	0.030	0.018	0.038	1.557	1.272	1.153
1983	0.138	0.178	0.097	0.397	0.192	0.030	0.123	0.467	0.152	0.051	0.065	0.013	0.021	0.190	1.701	1.304	1.112
ALFRED NEEDLER (summer)																	
1983	0.111	0.125	1.067	1.644	0.174	0.075	0.103	0.321	0.134	0.059	0.053	0.019	0.032	0.009	2.623	0.979	0.805
LADY HAMMOND (fall)																	
1979	0.000	0.000	0.146	3.612	5.395	1.511	0.357	0.332	0.112	0.160	0.031	0.000	0.009	0.119	11.638	8.026	2.631
1980	0.000	0.003	0.007	0.151	1.668	1.566	0.898	0.213	0.181	0.000	0.013	0.000	0.000	0.044	4.734	4.583	2.915
1981	0.000	1.253	0.236	0.262	1.269	1.763	0.858	0.443	0.095	0.036	0.000	0.068	0.000	0.011	4.805	4.543	3.274

Table 13. Estimated total population numbers ($\times 10^{-3}$) from the Canadian summer bottom trawl surveys, strata 43 - 95.

	A.T. CAMERON												LADY	HAMMOND	ALFRED NEEDLER
Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1983
2	8879	3579	479	1929	203	37	161	1290	19	0	2826	774	1023	706	496
3	2181	2666	939	1849	4677	89	989	3743	852	47	3350	871	11574	385	4231
4	1330	822	6187	5731	1171	1541	2825	4873	3118	3285	9525	287	1130	1574	6518
5	972	199	1838	2007	1537	1386	4992	10081	4587	3794	16901	2720	472	761	690
6	951	92	570	276	832	1822	1202	7080	1691	2817	5865	1913	1435	119	297
7	792	147	165	110	943	305	1983	1001	1543	1158	3540	1251	1265	488	408
8	479	55	294	202	547	452	718	1775	482	755	1339	1084	634	1852	1273
9	184	36	254	252	418	142	202	598	213	56	514	347	508	603	531
10	159	110	129	18	260	18	220	313	9	185	304	338	301	202	234
11	214	187	55	129	621	36	92	166	0	0	0	125	87	258	210
12	56	0	37	56	222	0	93	74	74	0	0	0	119	52	75

Table 14. Percent of the estimated population numbers by age in the Canadian summer bottom trawl survey series (%).

	A.T. CAMERON												LADY	HAMMOND	ALFRED NEEDLER
Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1983
2	55	45	4	15	2	1	1	4	0	0	6	8	6	10	3
3	13	34	9	15	41	2	7	12	7	0	8	9	62	5	28
4	8	10	57	46	10	26	21	16	25	27	22	3	6	22	43
5	6	3	17	16	13	24	37	33	36	31	38	28	3	11	5
6	6	1	5	2	7	31	9	23	13	23	13	20	8	2	2
7	5	2	2	1	8	5	15	3	12	10	8	13	7	7	3
8	3	1	3	2	5	8	5	6	4	6	3	11	3	26	9
9	1	0	2	2	4	2	1	2	2	0	1	4	3	9	4
10	1	1	1	0	2	0	2	1	0	2	1	3	2	3	2
11	1	2	1	1	5	1	1	1	0	0	0	1	0	4	1
12	0	0	0	0	2	0	1	0	1	0	0	0	1	1	0

Table 15. Stratified mean catch-per-tow in weight (kg) and numbers for Scotian Shelf, Gulf of Maine, and Georges Bank pollock in NEFC[1] offshore spring[2], summer[3], and autumn[4,1] bottom trawl surveys, 1963-1983.

Year	SPRING[4]		SUMMER		AUTUMN	
	Weight	Numbers	Weight	Numbers	Weight	Numbers
1963	-	-	10.28	2.31	5.79	1.46
1964	-	-	5.27	2.06	4.40	1.64
1965	-	-	2.56	1.72	2.74	0.83
1966	-	-	-	-	2.35	0.97
1967	-	-	-	-	1.80	0.52
1968	4.47	1.09	-	-	3.17	0.69
1969	2.66	1.12	1.75	0.70	6.58	1.31
1970	4.91	1.67	-	-	2.59	0.64
1971	4.39	1.18	-	-	3.96	1.09
1972	5.67	4.43	-	-	4.37	1.41
1973	4.82	4.00	-	-	4.71	1.64
1974	4.10	1.39	-	-	3.17	0.90
1975	5.90	1.67	-	-	2.04	0.70
1976	6.84	1.59	-	-	16.66	3.69
1977	3.44	1.63	9.98	2.07	8.78	2.14
1978	6.56	2.48	4.05	1.29	5.83	0.98
1979	4.75	1.06	17.57	2.96	5.81	1.28
1980	4.40	1.52	9.83	12.21	4.63	0.83
1981	6.30	2.00	-	-	7.75	5.24
1982	6.62	3.99	-	-	3.40	1.40
1983	1.84	0.90	-	-	2.68	0.87

[1] NEFC = Northeastern Fisheries Centre

[2] Strata 13-40.

[3] Strata 21-28 and 37-40.

[4] The "36 Yankee" trawl was used from 1968-1972, and the "41 Yankee" trawl was used from 1973-1983. No gear conversion factors are available to adjust for differences in fishing power.

Table 16. U.S.A Research Survey catch rates at age (Nos. per standard tow).

	SPRING														SUMMER				AUTUMN											
Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1977	1978	1979	1980	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.01	0.01																	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01		
1	0.52	0.15	1.20	0.01	0.01	0.01	0.08	0.14	0.00	0.10	0.15	0.01	0.13	0.57	0.05	0.00	0.05	10.67	0.13	0.11	0.38	0.03	0.00	0.22	0.03	0.06	0.03	0.01	0.13	0.07	0.07
2	0.05	0.13	1.49	2.80	0.10	0.33	0.11	0.38	0.22	0.05	0.15	0.72	1.63	0.05	0.23	0.57	0.00	0.11	0.08	0.38	0.27	0.71	0.08	0.06	0.03	0.17	0.19	0.02	0.01	3.59	0.44
3	0.17	0.13	0.90	0.51	0.53	0.20	0.14	0.23	0.42	0.07	0.09	0.13	0.84	0.02	0.09	0.17	0.38	0.06	0.01	0.16	0.20	0.12	0.28	0.03	0.15	0.24	0.04	0.26	0.01	0.98	0.40
4	0.20	0.09	0.20	0.15	0.14	0.34	0.15	0.06	0.65	0.08	0.28	0.12	0.55	0.03	0.26	0.09	0.26	0.29	0.09	0.02	0.08	0.17	0.20	0.11	0.55	0.29	0.04	0.33	0.05	0.14	0.29
5	0.05	0.07	0.05	0.14	0.08	0.08	0.24	0.16	0.63	0.15	0.25	0.18	0.11	0.00	0.29	0.08	0.36	0.25	0.08	0.06	0.07	0.11	0.11	0.07	1.63	0.42	0.09	0.19	0.11	0.20	0.01
6	0.07	0.08	0.05	0.04	0.16	0.09	0.13	0.32	0.15	0.14	0.20	0.26	0.33	0.00	0.32	0.08	0.55	0.30	0.08	0.09	0.08	0.11	0.08	0.04	0.50	0.38	0.09	0.13	0.06	0.13	0.05
7	0.09	0.04	0.07	0.03	0.07	0.10	0.15	0.13	0.11	0.08	0.23	0.08	0.11	0.05	0.15	0.05	0.36	0.22	0.04	0.04	0.07	0.09	0.09	0.09	0.31	0.22	0.15	0.08	0.07	0.04	0.04
8	0.12	0.09	0.12	0.10	0.03	0.08	0.17	0.11	0.08	0.16	0.08	0.07	0.14	0.04	0.23	0.09	0.49	0.03	0.02	0.08	0.05	0.07	0.01	0.01	0.14	0.11	0.08	0.09	0.13	0.00	0.02
9	0.08	0.06	0.04	0.04	0.00	0.05	0.11	0.02	0.07	0.08	0.04	0.05	0.05	0.01	0.07	0.03	0.06	0.02	0.01	0.03	0.04	0.00	0.02	0.01	0.05	0.09	0.06	0.05	0.08	0.00	0.02
10	0.04	0.07	0.07	0.09	0.01	0.06	0.03	0.02	0.05	0.03	0.02	0.09	0.01	0.02	0.08	0.01	0.21	0.07	0.02	0.01	0.03	0.12	0.00	0.01	0.01	0.02	0.04	0.04	0.06	0.01	0.00
11	0.04	0.07	0.04	0.02	0.10	0.02	0.04	0.01	0.04	0.03	0.00	0.06	0.02	0.02	0.07	0.05	0.00	0.05	0.01	0.01	0.03	0.02	0.02	0.01	0.01	0.00	0.03	0.01	0.04	0.00	0.02
12+	0.23	0.20	0.17	0.09	0.16	0.29	0.24	0.04	0.07	0.08	0.05	0.20	0.07	0.10	0.23	0.08	0.23	0.13	0.07	0.09	0.10	0.10	0.02	0.03	0.29	0.14	0.12	0.06	0.07	0.08	0.04
Totals																															
1+	1.66	1.18	4.40	4.02	1.39	1.65	1.59	1.62	2.49	1.05	1.54	1.97	3.99	0.91	2.07	1.30	2.95	12.20	0.64	1.08	1.40	1.65	0.91	0.69	3.70	2.14	0.96	1.27	0.82	5.24	1.40
2+	1.14	1.03	3.20	4.01	1.38	1.64	1.51	1.48	2.49	0.95	1.39	1.96	3.86	0.34	2.02	1.30	2.90	1.53	0.51	0.97	1.02	1.62	0.91	0.47	3.67	2.08	0.93	1.26	0.69	5.17	1.33
3+	1.09	0.90	1.71	1.21	1.28	1.31	1.40	1.10	2.27	0.90	1.24	1.24	2.23	0.29	1.79	0.73	2.90	1.42	0.43	0.59	0.75	0.91	0.83	0.41	3.64	1.91	0.74	1.24	0.68	1.58	0.89
4+	0.92	0.77	0.81	0.70	0.75	1.11	1.26	0.87	1.85	0.83	1.15	1.11	1.39	0.27	1.70	0.56	2.52	1.36	0.42	0.43	0.55	0.79	0.55	0.38	3.49	1.67	0.70	0.98	0.67	0.60	0.49
5+	0.72	0.68	0.61	0.55	0.61	0.77	1.11	0.81	1.20	0.75	0.87	0.99	0.84	0.24	1.44	0.47	2.26	1.07	0.33	0.41	0.47	0.62	0.35	0.27	2.94	1.38	0.66	0.65	0.62	0.46	0.20

Table 17. Stratified mean catch-per-tow in numbers and weight (kg) for pollock in the Massachusetts inshore spring surveys[1] and NEFC inshore summer surveys[2], 1977-1983.

Year	Stratified Mean Catch-Per-Tow in Numbers AGE 0	1	2	3	4+	Total	Stratified Mean Catch-Per-Tow in Weight (kg)
NEFC (Summer)							
1977	0.00	1.11	0.82	0.00	0.00	1.93	0.61
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	1.17	0.35	0.00	0.00	0.00	1.52	0.18
1980	0.17	0.33	0.00	0.00	0.00	0.50	0.06
Massachusetts (Spring)							
1978	2.07	0.01	0.13	0.06	0.00	2.27	0.11
1979	4.34	0.04	0.01	0.06	0.00	4.45	0.07
1980	0.30	8.37	0.20	0.02	0.00	8.89	0.72
1981	1.52	1.42	1.40	0.00		4.34	0.54
1982	1.79	0.00	0.06	0.00	-	1.85	0.03
1983	0.03	6.45	0.27	0.04		6.79	0.68

[1] Regions 1-5 (STRATA 11-21 and 25-36).

[2] Inshore STRATA 52, 55, 56, 58-61, 63-66, 72, 74, and 75.

Table 18. Research vessel survey catch rates (nos. per standard tow) for pollock in NAFO Divs. 4VWX, SA 5, and 6.

Research Cruises	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
U.S.A. autumn bottom trawl survey (No tow^{-1})	0.90	0.70	3.69	2.14	0.98	1.27	0.82	5.24	1.40	-
U.S.A. spring bottom trawl survey (No tow^{-1})	1.39	1.65	1.59	1.63	2.47	1.06	1.51	1.97	3.99	0.91
U.S.A. summer bottom trawl survey (No tow^{-1})	-	-	-	2.07	1.30	2.95	12.20	-	-	-
Canada summer bottom trawl survey (No Tow^{-1})										
A.T. CAMERON	2.48	1.27	2.95	6.72	2.88	2.77	9.55	2.15	-	-
LADY HAMMOND	-	-	-	-	-	-	-	-	4.73	2.11
ALFRED NEEDLER	-	-	-	-	-	-	-	-	-	3.93
Canada fall bottom trawl survey (No tow^{-1})										
LADY HAMMOND	-	-	-	-	-	11.78	4.74	6.29	-	-

Table 19. Commercial catch rates (t/hr) for pollock in Divs. 4VWX and SA 5 (POK = pollock; MSP = main species).

Canadian OTB-1,2 (TC5) CPUE ($t\text{-}hr^{-1}$)										
All Months (POK = MSP)	0.67	0.72	0.58	1.008	1.34	1.34	1.09	1.51	1.50	1.17
January - June										
i) POK = MSP	0.77	0.75	0.65	0.84	1.14	1.22	1.21	1.44	1.54	1.37
ii) (all catches 50% of total) (McGlade *et al.* 1983)	0.76	0.69	0.67	0.83	1.05	1.29	1.23	1.28	1.27	1.20
June-December (POK = MSP)	0.65	0.70	0.57	1.07	1.22	1.21	1.02	1.61	1.57	0.98
June-August (POK = MSP)	0.58	0.61	0.54	0.72	1.16	1.16	1.04	1.93	1.69	1.02

Table 20. Fishing effort calculated with total landings divided by catch rates for pollock in Divs. 4VWX and SA 5.

Research Cruises	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
COMMERCIAL CATCH RATES										
Canadian OTB-1,2 (TC5) (CPUE)										
All Months (POK = MSP)	56421	54215	64838	38096	33811	34799	50851	39009	35561	34935
January - June										
i) (POK = MSP)	49094	52047	57855	45715	39743	38222	45808	40906	34638	29835
ii) (all catches ≥50% of total) (McGlade *et al.* 1983)	53926	56737	56216	46379	43315	36148	45100	45322	40497	34062
June-December (POK = MSP)	58157	55764	65975	35889	37137	38538	54341	36586	33976	41708
June-August (POK = MSP)	65176	63992	69641	53335	39058	40199	53296	30520	31563	40073

Table 21. Total mortality coefficients (Z) for pollock in Divs. 4VWX and SA 5 from total commercial catch-at-age data using fishing effort estimated from Canadian commercial OTB-1, 2 (TC5) catch rates.

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Numbers										
5-10	6114	4358	6966	7335	8738	7675	11782	12355	7657	7901
6-11	2592	2515	2548	4948	5184	3791	5459	5983	7149	2315
(i) TC5 Effort (POK = MSP)										
January-June	49094	52047	57855	45715	39743	38222	45808	40906	34638	29835
Numbers/Effort										
5-10	.1245	.0837	.1204	.1605	.2199	.2008	.2572	.3020	.2211	.2648
6-11	.0528	.0483	.0440	.1082	.1304	.0992	.1192	.1463	.2064	.0776
Z	.9469	.6431	.1068	.2077	.7960	.5215	.5642	.3806	1.0471	
(ii) TC5 Effort (POK ≥50%)										
January-June	53926	56737	52616	46379	43315	36148	45100	45322	40497	34062
Z	3.25	.46	.15	.28	.52	.56	.68	.44	1.02	
(iii) TC5 Effort (POK = MSP)										
June-August	65176	63992	69641	53335	39058	40199	53296	30520	31563	40073
Numbers/Effort										
5-10	.0938	.0681	.1000	.1375	.2237	.1909	.2211	.4048	.2426	.1972
6-11	.0398	.0393	.0366	.0928	.1327	.0943	.1024	.1960	.2265	.0578
Z	.8699	.6209	.0747	.0355	.8638	.6229	.1205	.5807	1.4344	
(iv) TC5 Effort (POK = MSP)										
June-December	58157	55764	65975	35889	37137	38538	54341	36586	33976	41708
Numbers/Effort										
5-10	.1051	.0782	.1056	.2044	.2353	.1992	.2168	.3377	.2254	.1894
6-11	.0446	.0451	.0386	.1379	.1396	.0984	.1005	.1635	.2104	.0555
Z	.8460	.7060	-.2669	.3813	.8718	.6842	.2822	.4732	1.4015	
(v) TC5 Effort (POK = MSP)										
All Months	56421	54215	64838	38096	33811	34799	50851	39009	35561	34935
Numbers/Effort										
5-10	.1084	.0804	.1074	.1925	.2584	.2206	.2317	.3167	.2153	.2262
6-11	.0459	.0464	.0393	.1299	.1533	.1089	.1074	.1534	.2010	.0663
Z	.8485	.7158	-.1902	.2277	.8644	.7198	.4124	.4547	1.1778	

Table 22. Calibration of cohort analysis results for a range of fishing mortalities based on least squares regressions (intercept and slope), and correlation coefficients (v). 1983 point not included in analyses. P = predicted value for 1983; 0 = observed value for 1983.

	Fully Recruited											
	$F_{.175}$		$F_{.20}$		$F_{.25}$		$F_{.275}$		$F_{.3}$		$F_{.35}$	
	P	0	P	0	P	0	P	0	P	0	P	0
OTB - 1,2 (TC5) vs 5+ biomass	96477	89214	90258	78062	81507	62450	78312	56772	75667	52041	75541	44607
slope	87223		74821		57548		51295		46022		37520	
int	-8191		473		12449		16758		20441		26460	
r	.839		.802		.709		.661		.61		.52	
	P	0	P	0	P	0	P	0	P	0	P	0
OTB, 1,2 (TC5) vs exploitable biomass (mid-year) (using annual selectivities)	149957	208175	139662	182153	125201	145722	119930	132495	108696	121435	99176	104087
slope	109166		89016		60920		50740		34479		21682	
int	18958		32843		52097		59044		74462		83010	
r	.702		.682		.606		.550		.34		.22	
	P	0	P	0	P	0	P	0	P	0	P	0
OTB - 1,2 (TC5) vs exploitable biomass (mid-year) (using average selectivity)	156437	201597	145461	184382	129396	145577	123827	132422	119695	123652	104534	102736
slope	127569		106079		75670		64831		56181		39895	
int	3355		18166		38594		46030		52278		63914	
r	.315		.827		.826		.798		.74		.58	

Table 23. Results of the cohort analysis at F = 0.2 for pollock.

MEAN POPULATION BIOMASS (t) 9/ 5/84

Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	21152	28370	32431	48041	30910	9379	23770	106690	18520	1220
3	45465	28719	38074	34014	43589	38425	14093	25950	120907	22846
4	19916	44776	28514	26425	34054	56794	42712	10016	25738	119327
5	19256	18330	35929	18459	28077	40178	56113	29345	6373	22005
6	8932	15601	14025	22668	14535	22974	27627	38090	19409	4819
7	5469	6898	9632	8816	16468	9949	14869	20529	27693	13257
8	2827	4738	4115	6094	4990	11424	8178	12312	14284	21834
9	1884	1681	3403	2976	3081	2523	7368	5314	7756	9657
10	1806	1217	1208	2907	1690	1624	1762	6006	2756	4991
11	1647	1053	719	794	1936	981	1104	992	3694	1499
2+	128353	151383	168051	171195	179330	194249	197595	255245	247131	221456
3+	107201	123013	135620	123153	148419	184871	173825	148555	228611	220236
4+	61736	94294	97546	89139	104830	146446	159732	122605	107703	197389
5+	41820	49518	69032	62714	70776	89652	117020	112588	81965	78062

POPULATION NUMBERS ($\times 10^{-3}$) 9/ 5/84

Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	30640	37220	46776	60193	41848	12095	22825	121469	25467	2414
3	44154	24528	30137	37832	48947	34085	9691	18355	97478	20577
4	13243	29562	17054	22003	27783	37339	24624	6402	12839	74394
5	10763	8228	16572	10721	14420	18507	24826	15662	2549	8190
6	3810	5532	5027	9540	5673	8490	11604	14562	7011	1444
7	1736	1918	3032	3000	5153	2994	4849	6338	8826	3543
8	832	958	1068	1613	1460	2345	1803	2882	3889	5235
9	409	307	659	640	769	598	1515	1154	1892	2020
10	360	234	201	514	367	299	317	1006	620	892
11	298	183	128	136	345	163	178	170	646	231
2+	106245	108670	120654	146190	146766	116915	102230	187999	161215	118939
3+	75605	71450	73879	85997	104918	104820	79405	66529	135749	116525
4+	31451	46922	43742	48166	55971	70735	69714	48174	38271	95948
5+	18208	17360	26688	26163	28188	33396	45090	41773	25432	21554

Table 23. (continued).

FISHING MORTALITY 9/ 5/84

Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	0.023	0.011	0.012	0.007	0.005	0.022	0.018	0.020	0.013	0.008
3	0.201	0.163	0.115	0.109	0.071	0.125	0.215	0.157	0.070	0.075
4	0.276	0.379	0.264	0.223	0.206	0.208	0.252	0.721	0.250	0.160
5	0.466	0.293	0.352	0.436	0.330	0.267	0.333	0.604	0.369	0.200
6	0.486	0.401	0.316	0.416	0.439	0.360	0.405	0.301	0.482	0.200
7	0.395	0.385	0.431	0.520	0.587	0.307	0.320	0.288	0.322	0.200
8	0.798	0.173	0.312	0.540	0.692	0.237	0.246	0.221	0.455	0.200
9	0.360	0.221	0.050	0.357	0.746	0.435	0.209	0.421	0.552	0.200
10	0.479	0.402	0.193	0.197	0.612	0.320	0.424	0.243	0.789	0.200
11	0.476	0.332	0.344	0.438	0.434	0.296	0.343	0.409	0.422	0.200
5+	0.476	0.332	0.344	0.438	0.434	0.296	0.343	0.409	0.422	0.200

SELECTIVITY MATRIX 9/ 5/84

Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	0.048	0.038	0.035	0.016	0.016	0.081	0.054	0.033	0.036	0.041
3	0.432	0.558	0.325	0.249	0.214	0.469	0.644	0.261	0.191	0.375
4	0.593	1.293	0.750	0.510	0.626	0.780	0.757	1.194	0.677	0.800
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	1.044	1.371	0.898	0.953	1.332	1.349	1.214	0.498	1.309	1.000
7	0.847	1.316	1.224	1.192	1.781	1.152	0.961	0.478	0.874	1.000
8	1.714	0.592	0.885	1.238	2.100	0.889	0.738	0.366	1.234	1.000
9	0.773	0.754	0.141	0.818	2.263	1.632	0.628	0.698	1.498	1.000
10	1.029	1.372	0.548	0.451	1.857	1.199	1.271	0.402	2.141	1.000
11	1.022	1.134	0.977	1.003	1.316	1.109	1.029	0.677	1.145	1.000

Average Selectivity (1974-1982)

Age	2	3	4	5	6	7	8	9	10	11
	0.041	0.375	0.80	1	1	1	1	1	1	1

Table 24. Input parameters for catch projections for Divs. 4VWX and SA 5 pollock.

Age	1983 Population Numbers ('000)	Av. (1974-1983) Weights-at-Age (kg)	Partial Recruitment
2	2414	0.894	0.041
3	20577	1.443	0.375
4	74394	2.058	0.8
5	8190	2.923	1
6	1444	3.733	1
7	3543	4.533	1
8	5235	5.642	1
9	2020	6.302	1
10	892	7.308	1
11	231	8.219	1

Age 1 recruitment after 1983 was set at the GM of SPA age 1 numbers from 1974-1982 (32.6 million).

Table 25. Results of projection analysis.

a) TAC in 1984 (53,000 t) $F_{0.1}$ in 1985 (0.28).

Population Biomass			Catch Biomass		
	YEAR			YEAR	
Age	1984	1985	Age	1984	1985
2	29142	29142	2	278	302
3	2828	38106	3	237	3449
4	32162	2997	4	5461	547
5	151712	30417	5	31439	6764
6	20494	122517	6	4247	27245
7	4387	15736	7	909	3499
8	13399	3453	8	2777	768
9	22114	9464	9	4583	2105
10	9895	16215	10	2051	3606
11	4914	7037	11	1018	1565
2+	291051	275088	2+	53000	49849
3+	261908	245946	3+	52722	49548
4+	259080	207840	4+	52485	46099
5+	226917	204842	5+	47024	45552

b) $F_{0.1}$ in 1984 and 1985.

Population Biomass			Catch Biomass		
	YEAR			YEAR	
Age	1984	1985	Age	1984	1985
2	29142	29142	2	302	302
3	2828	38072	3	256	3445
4	32162	2973	4	5872	543
5	151712	29894	5	33737	6648
6	20494	119891	6	4557	26661
7	4387	15399	7	976	3424
8	13399	3379	8	2980	751
9	22114	9261	9	4918	2060
10	9895	15868	10	2200	3529
11	4914	6886	11	1093	1531
2+	291051	270769	2+	56891	48894
3+	261908	241626	3+	56589	48593
4+	259080	203554	4+	56333	45147
5+	226917	200580	5+	50461	44604

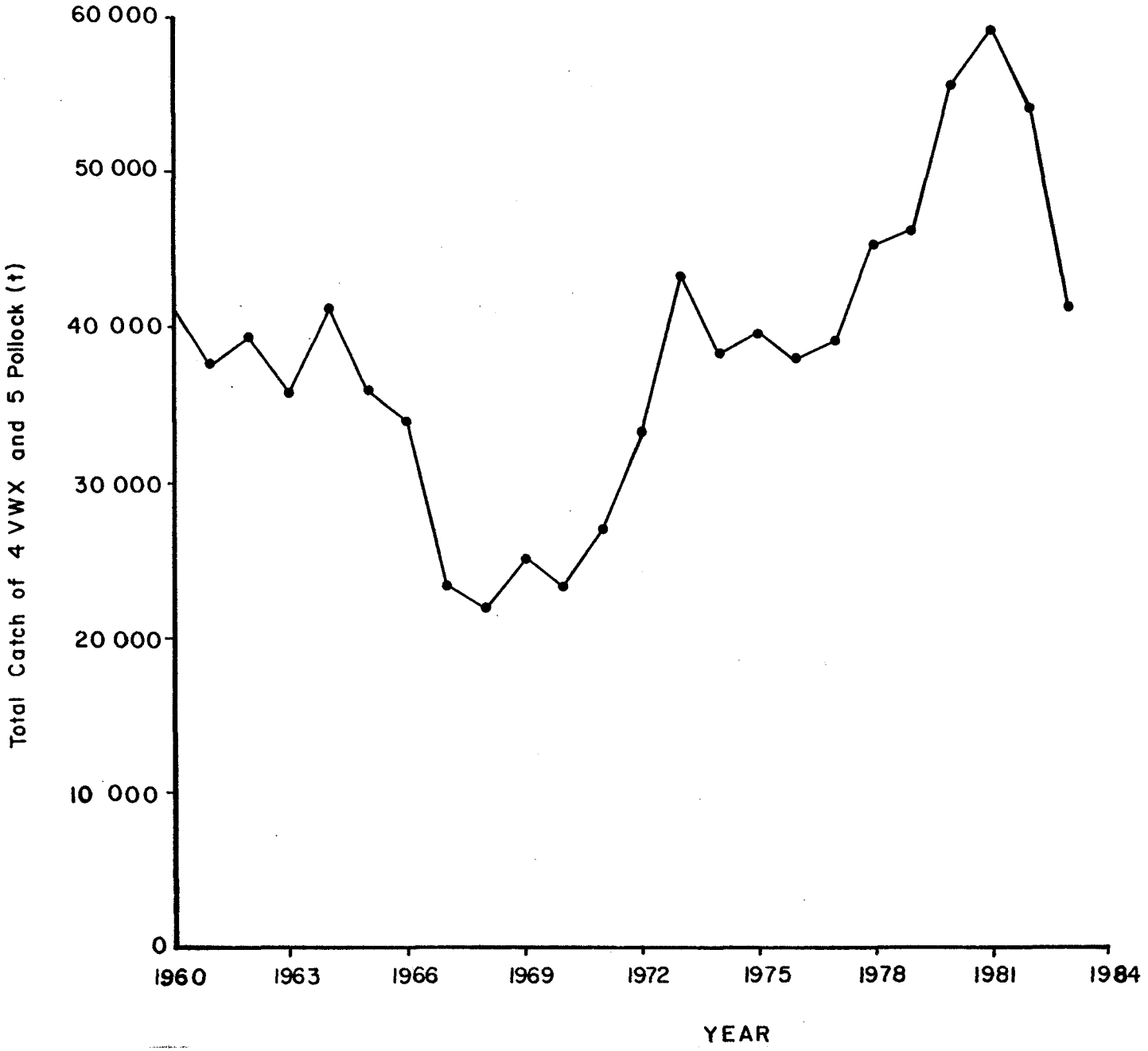


Figure 1. Nominal catch of pollock in Divs. 4VWX and SA 5 (t).

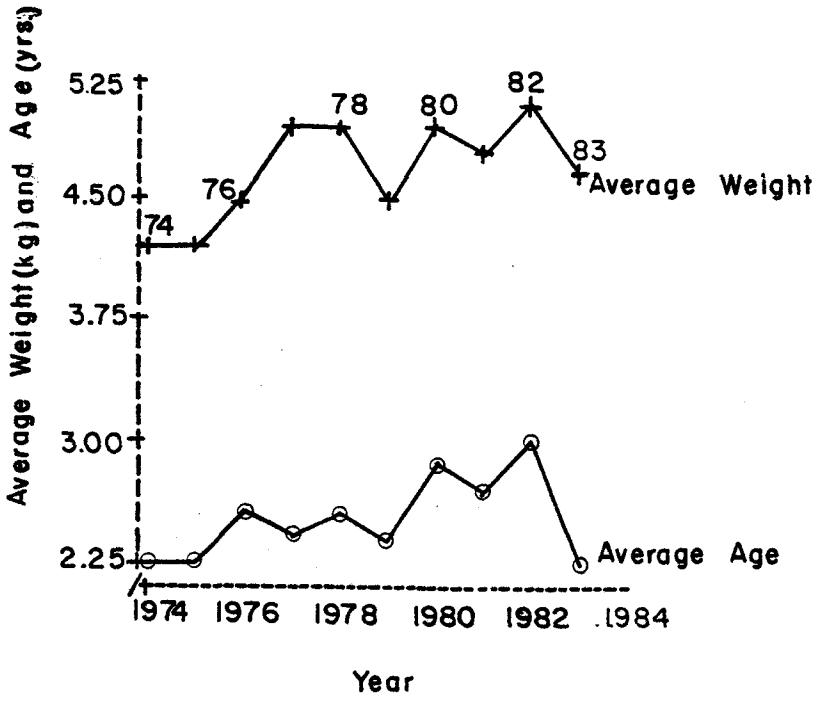


Figure 2. Average weight and age of pollock in the commercial catch.

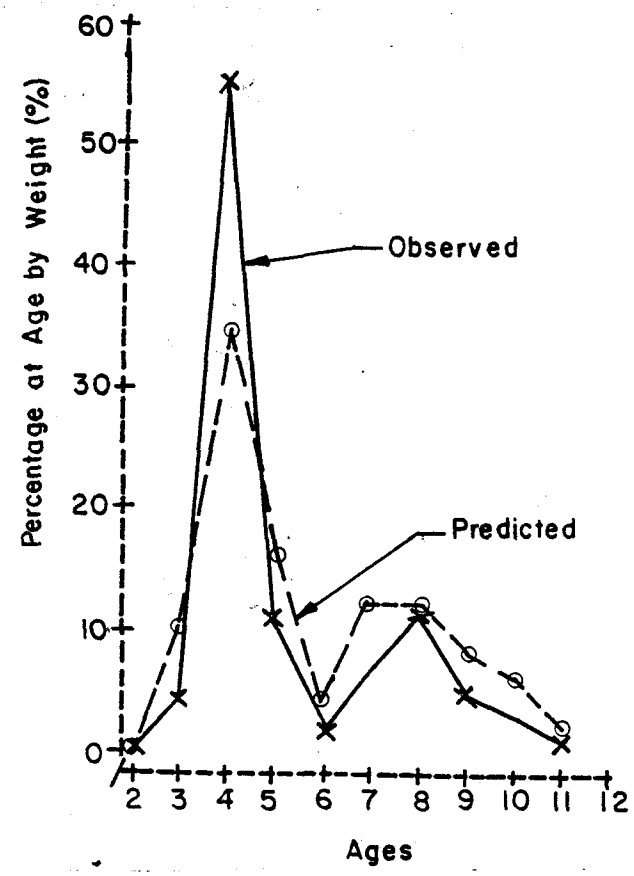


Figure 3. The predicted and observed percentage catch-at-age for pollock by weight for 1983.

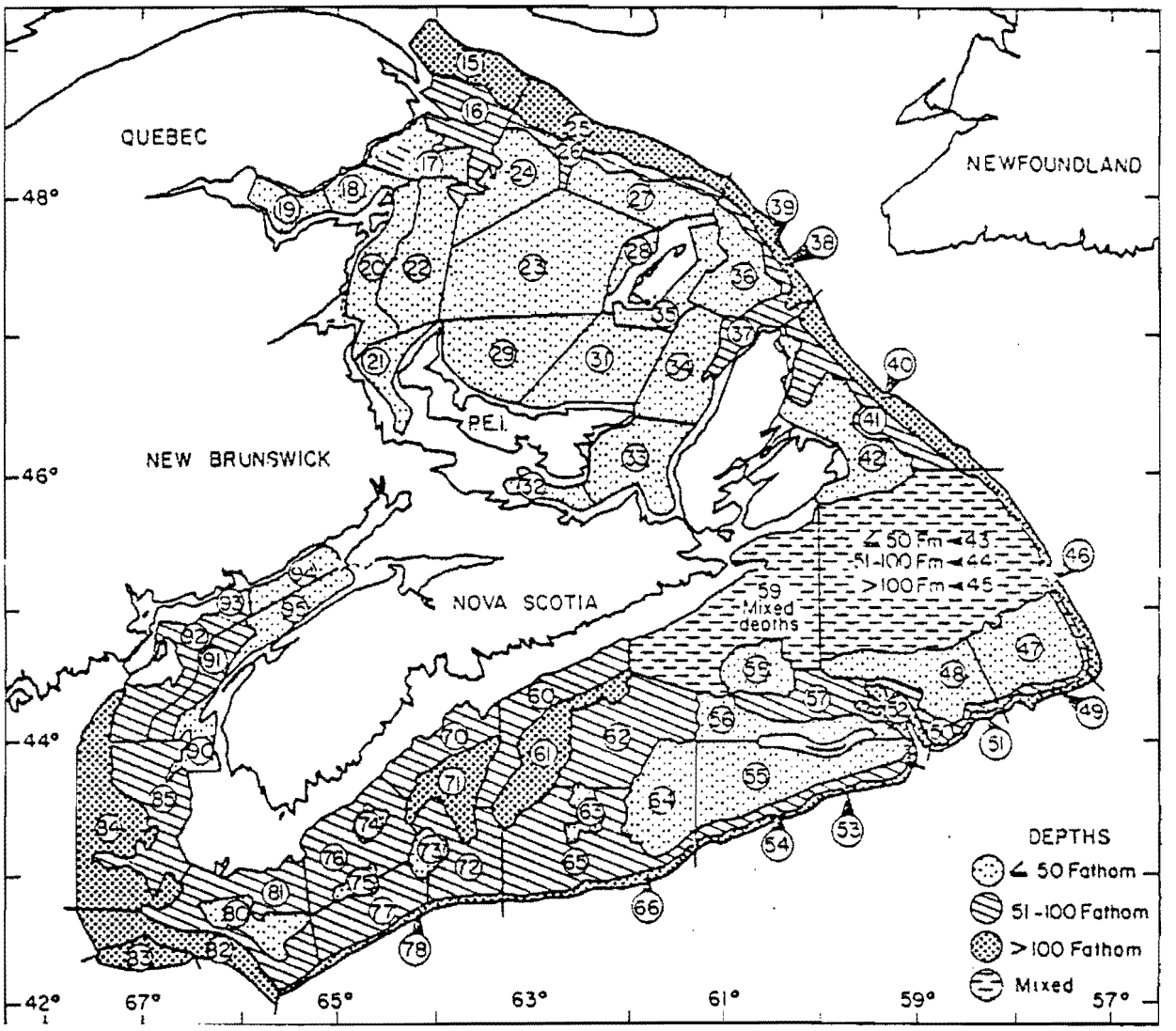


Figure 4. Strata used in the Canadian R.V. surveys

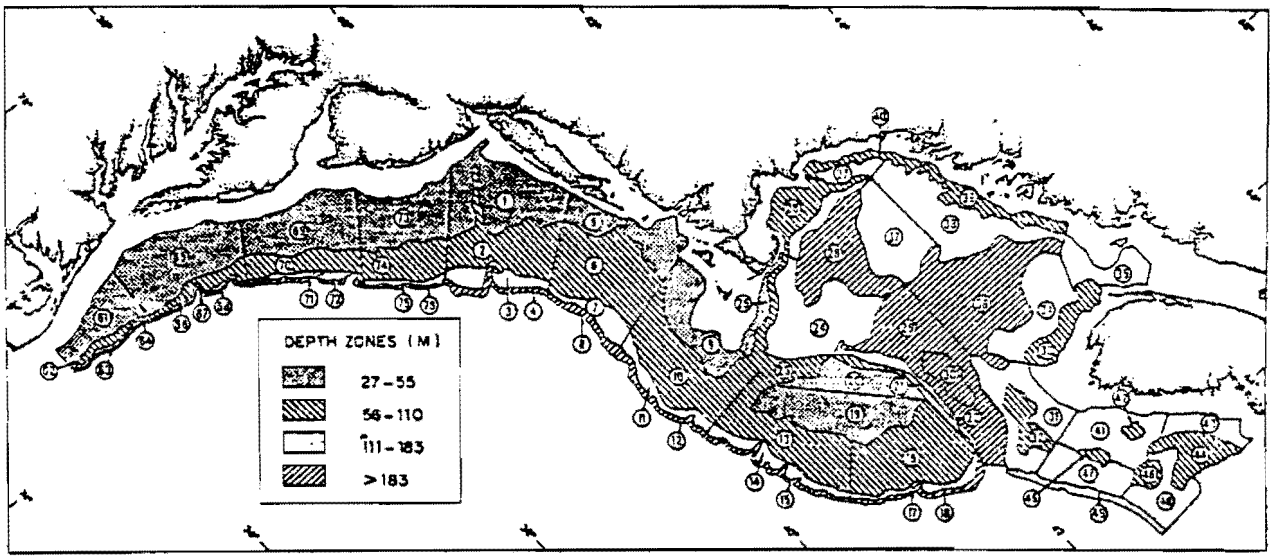


Figure 5. Strata used in the U.S. R.V. surveys

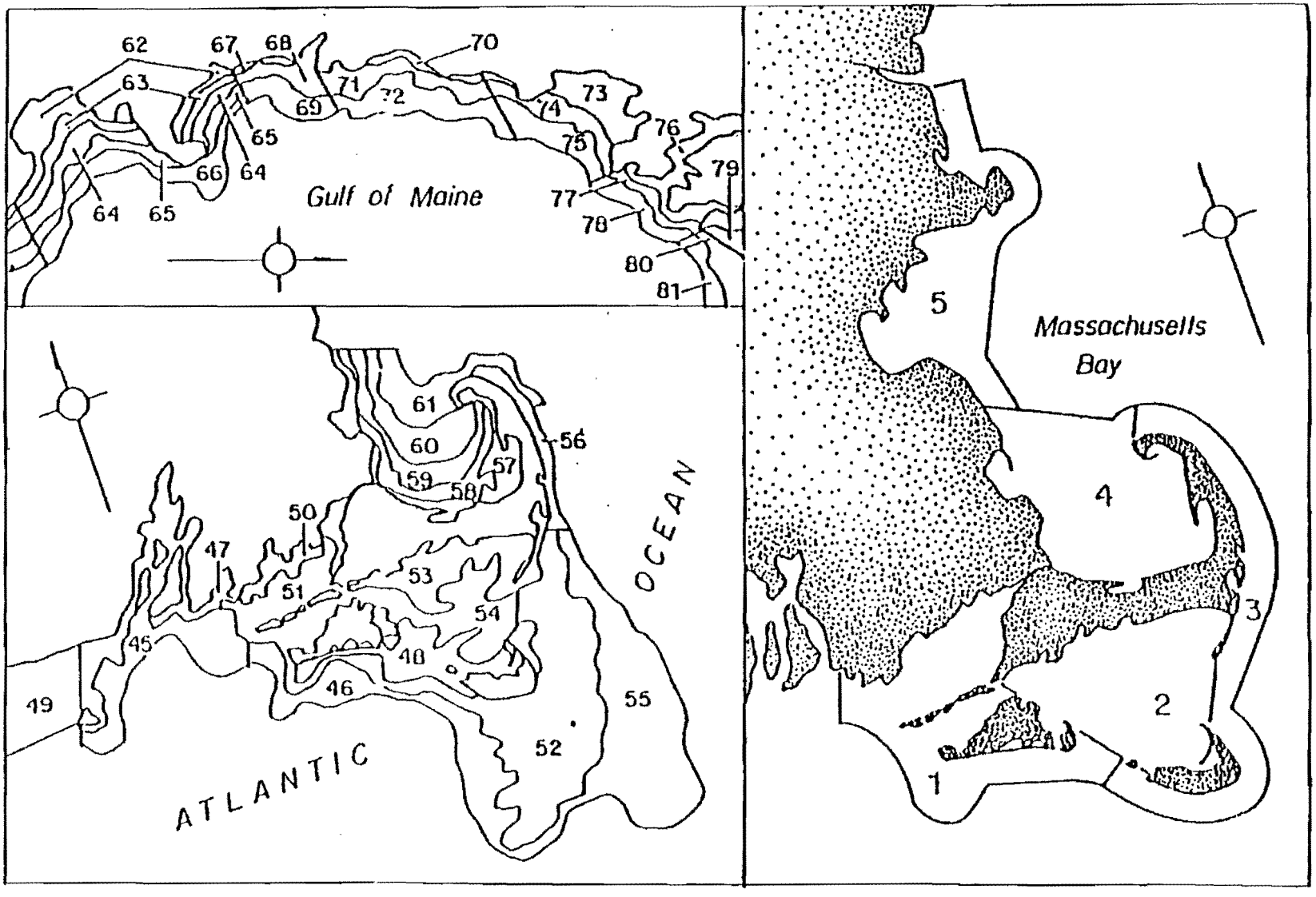


Figure 6. Strata used in NEFC inshore (<27m) spring, summer, and autumn bottom trawl surveys and strata groups used in Massachusetts spring and autumn inshore surveys.

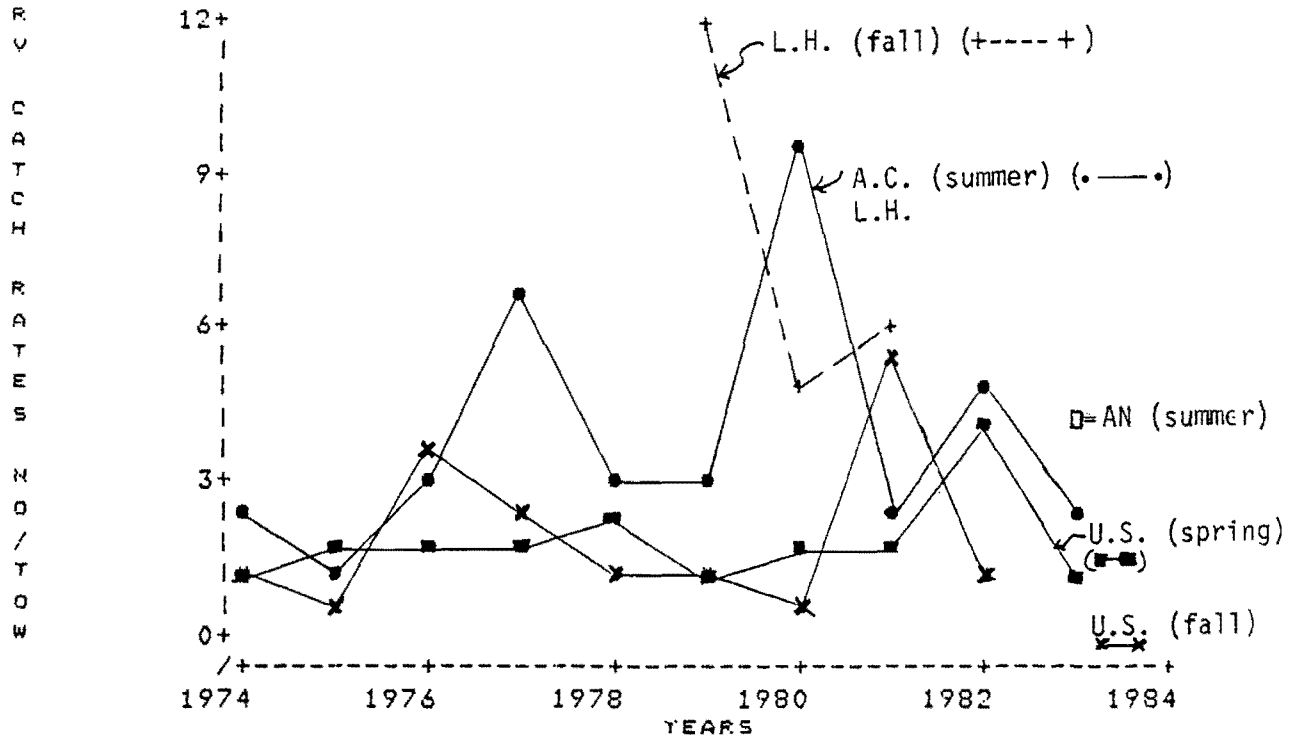


Figure 7. Trends in mean catch per tow (nos.) for pollock in Divs. 4VWX and SA 5 in R.V. surveys conducted by Canada and the U.S.A.

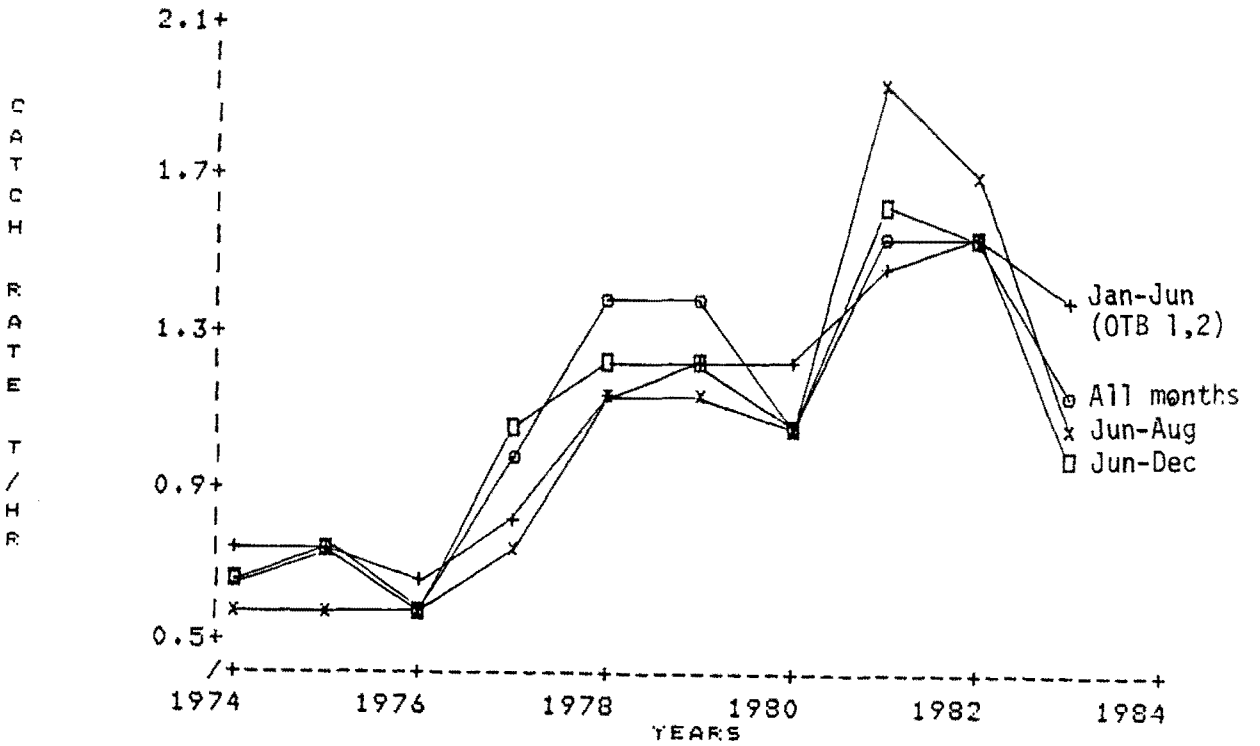
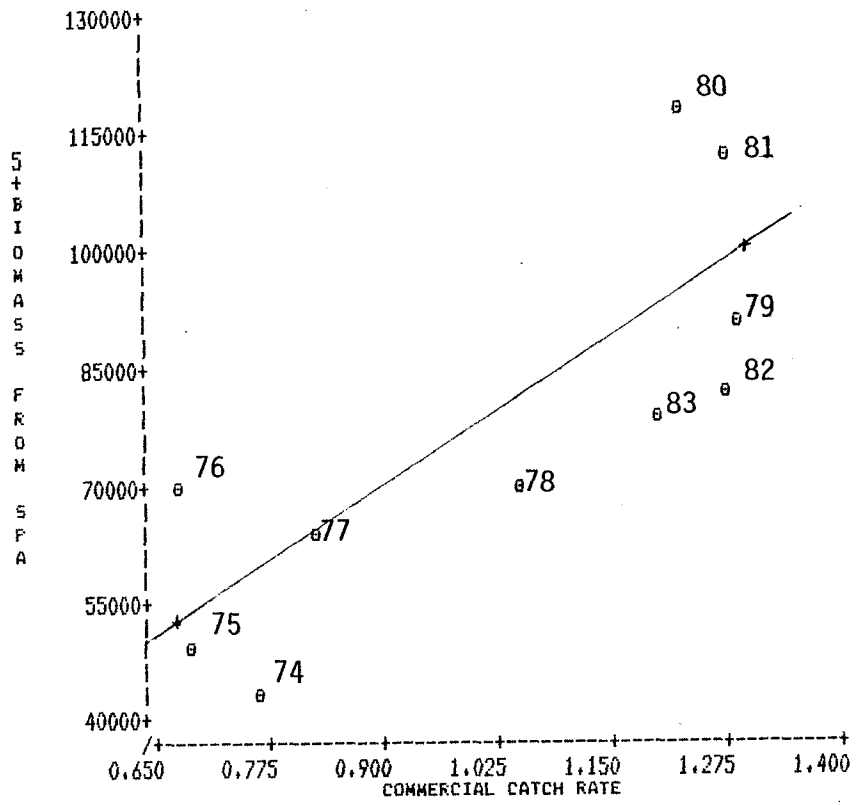
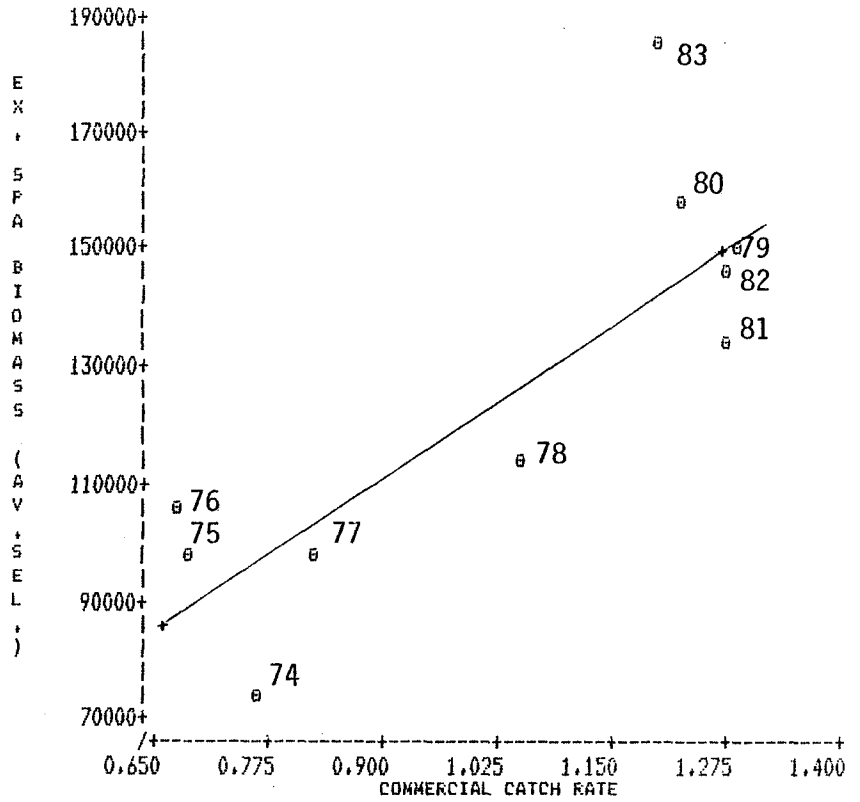


Figure 8. Trends in commercial catch rates (t/hr) of pollock in Divs. 4VWX and SA 5.

Figure 9. Calibration plots from the cohort analysis for pollock at $F_t = 0.20$, showing the least squares regression line. The commercial catch rate is for Canadian Maritime otter trawlers (OTB-1,2 (TC5)) for January to June for all catches for pollock ≥50% of the total catch.



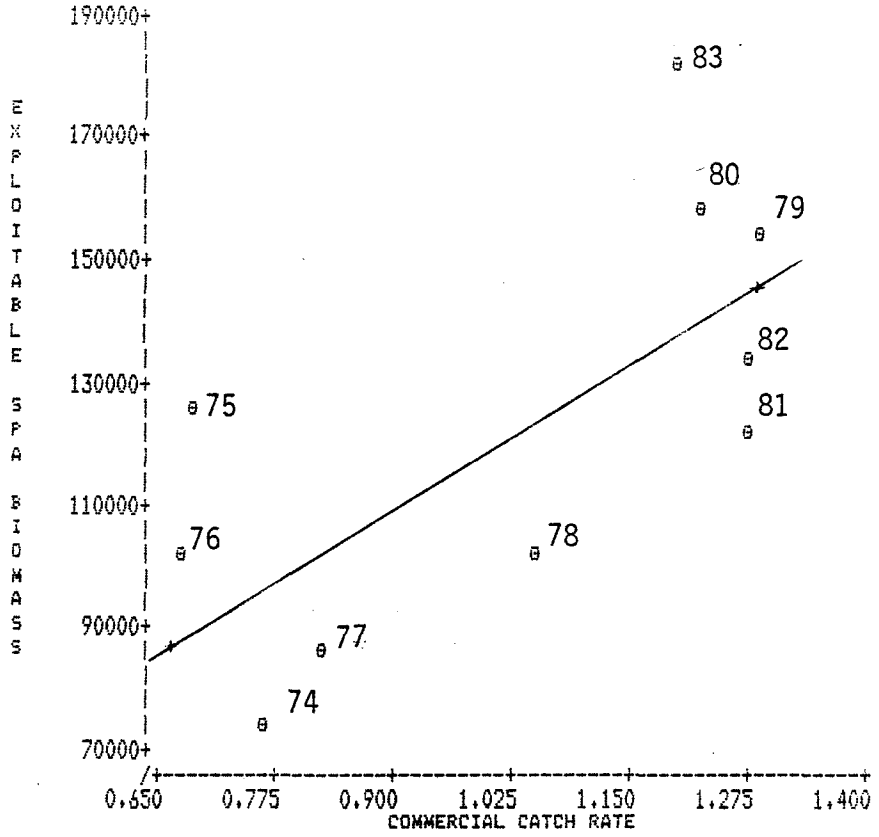


Intercept = 473 R = 0.802

	YEAR									
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
SPA 5+ biomass	41820	49518	69032	62714	70776	89652	117019	112588	81965	78062
Catch rate	0.76	0.69	0.67	0.83	1.05	1.29	1.23	1.28	1.27	1.20

Intercept = 18166 R = 0.827

	YEAR									
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
SPA exploitable	75585	97851	107592	98683	115838	150655	158141	134421	147950	184382
the average selectivity (1974-82)										
Catch rate	0.76	0.69	0.67	0.83	1.05	1.29	1.23	1.28	1.27	1.20



Intercept = 32843 R = 0.682

	YEAR									
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
SPA exploitable biomass	74291	124538	103929	85407	101913	152735	159707	134848	123111	182153
Catch rate	0.76	0.69	0.67	0.83	1.05	1.29	1.23	1.28	1.27	1.20

Figure 9. (continued)