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An assessment of the status of the cod stock in NAFO Divisions 4R & 4S and in subdivision 3Pn

by

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ABSTRACT

Nominal catches of cod from the 4RS 3Pn stock have increased in recent years from 74,000 t in 1977 to 105,000 in 1982 and to 103,000 t in 1983 (preliminary statistics). Catch rates were standardized to Canada-Maritime otter trawler TC4 using the multiplicative model combining catch rate data for country-gear, months, divisions and years. Standardized catch rate indices have increased in the same interval from 0.755 t/hour to 1.871 t/hour in 1982 and 1.668 t/hour in 1983. Exploitable biomass from cohort analysis (using a constant instantaneous rate of natural mortality of 0.2) provided the best relationship with catch rate series when a fully recruited fishing mortality of 0.275 was assumed for 1983. Projections for 1985 at $F_{0.1}$ indicated a catch of 90,000 t assuming that the TAC of 100,000 t will be taken in 1984.

RÉSUMÉ

Les captures nominales de morue provenant du stock de 4RS 3Pn ont augmenté au cours des dernières années de 74,000 t en 1977 à 105,000 t en 1982 et 103,000 t en 1983 (données préliminaires). Les taux de capture standardisés ont aussi augmenté au cours de la même période de 0.755 t/heure à 1.871 t/heure en 1982 et 1.688 t/heure en 1983. Les taux de captures ont été standardisé sur les chalutiers (TC4) canadiens des provinces maritimes en utilisant le modèle multiplicatif qui permet de combiner des données provenant de pays-engins, mois, divisions et années. La meilleure relation entre les taux de capture et les estimés de biomasse exploitable produit par des analyses de cohorte (avec un taux instantané constant de mortalité naturelle de 0.2) a été obtenue quand une mortalité par pêche $F_T = 0.275$ a été utilisée en 1983 sur les âges pleinement recrutés. Une prise de 90,000 t à $F_{0.1}$ a été prédite pour 1985 en supposant que le TPA de 100,000 t va être pris en 1984.

1. INTRODUCTION

The cod fishery in NAFO Divisions 3Pn, 4R and 4S has been prosecuted historically in two distinct components: a winter fishery on the southwest coast of Newfoundland (Divisions 3Pn and southern 4R) and a summer fishery in divisions 4R and 4S (Table 1). Landings from this cod stock have fluctuated between 58,200 and 105,000 t (Figure 1, Table 1). Between 1959 and 1976, Canadian catches have averaged 53% of the totals while French, Portuguese and other foreign fleets landed respectively 23%, 5% and 9% of the total catches (Table 2). Since 1977 the French component of the catch has been limited to 15% of the TAC while the remainder was caught in a 3 to 1 ratio by Newfoundland and Quebec based vessels. Catches by maritime based vessels have been relatively small (3-5%). A breakdown of the landings into main gear categories is given in Table 3.

2. NOMINAL CATCHES

The 1983 nominal catch statistics (Table 4) for Newfoundland and Maritime based vessels were obtained from the respective Statistics branches of the Department of Fisheries and Oceans. Catch statistics for the Quebec based vessel were obtained from Le Bureau de la Statistique du Québec and data for the French fleet operating in the Gulf were obtained through the FLASH system. Preliminary 1983 catch was estimated at 102,647 t, exceeding the TAC by 2,647 t. This represents a small decrease relative to the final 1982 catch of 104,939 t (Tables 2, 3). Allocations were reached or exceeded by all fleet components, with the exception of mobile gears operating in division 4S.

3. CATCH AND EFFORT DATA

Historical commercial catch and effort data, with the exception of Quebec based vessels, were obtained from the NAFO Statistical Bulletins. Historical catch and effort data for Quebec-based vessels (from 1975 onward) were obtained from the Direction de la recherche, ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (J.P. Lussia-Berdou, personnal communication). Data for 1983 were obtained with the nominal catch statistics.

The catch rate data were analysed using the multiplicative model (Gavaris, 1980). The series was analysed in a single unit as done in last year assessment (Gascon, 1983). Data entries with values of effort less than 10 hours, or catches of less than 10 tonnes were deleted from the data set because of possible large rounding off in the statistical tables. A weighting factor, estimated from the residuals of an unweighted regression (averaged on 5 levels of effort values) was applied to the CPUE data. Results of the analysis are presented in Tables 5 to 7 and in Figure 2.

Catch rate values have declined slightly in 1983 after having reached their highest levels in 1982.

4. RESEARCH SURVEY DATA

Biomass estimates of cod from the random stratified surveys conducted in Divisions 4R, 4S and 3Pn between 1978 and 1984 on the Gadus Atlantica are given in table 8. Biomass estimates were broken down into stratum surveyed on the particular trips. No survey was conducted in 1982. The surveys were all conducted in the January- February period. The coverage of Div. 4S is quite variable, owing to weather and ice conditions at that time of the year in the area. The results of the research surveys show high year to year variability; they indicate nonetheless a substantial increase in biomass between 1978 & 1984 (Fig. 3).

5. CATCH AT AGE

Biological sampling data of the catch were obtained from several sources: for Canadian landings from the Research branches of the Quebec and Gulf regions and "Corporation de développement des pêches" (CODEP) and the foreign Observer Program (Quebec region) for catches by the French Fleet (Table 9).

Quarterly catches at age were calculated for the main components of the fishery. Quarterly length frequencies for inshore gears and trawlers were obtained from a weighted (by nominal catch) average of monthly length frequencies for the different fleet components (Table 10). Quarterly catch at age for both inshore gears and trawlers were produced by applying the appropriate age-length keys to these lengths frequencies. These quarterly catch at ages were then combined to produce the catch at age vector for 1983 (Table 11). Average weights at age were obtained by applying the following length weight relationship to the length at age data (Hodder, 1964):

$$W_{kg} = 6.1575 \times 10^{-6} \times FL_{cm}^{3.087855}$$

The 1982 catch at age was updated using the final 1982 nominal catch statistics and the 1974-1981 catch at age was taken from Gascon (1983).

6. SEQUENTIAL POPULATION ANALYSIS

Virtual population analysis [VPA] (Gulland, in Pope, 1972) was performed using the catch at age matrix shown in Table 12a. By examination of the age specific mortality tables of preliminary runs of VPA, and from a

separable virtual population analysis (Pope and Shepherd, 1982), it appears that cod in NAFO Divisions 4RS 3Pn are fully recruited to the fishery at age 7 onward. The partial recruitments for ages 4, 5 and 6 were estimated as the average of partial recruitments for age 4 to 6 between 1974 and 1980 (Table 13). The partial recruitments in 1981 and 1982 were excluded as it appears that the fishery was aiming at the abundant 1977 and 1978 year classes (age 4 in 1981 and 1982 respectively). The historical partial recruitments were estimated as the ratio of the fishing mortality (Table 13) at age over the fully recruited fishing mortality from age 7 to 11. The fully recruited fishing mortality was estimated from the survival rate of fish aged 7 to 10 in one year and aged 8 to 11 in the next.

VPA were produced using values for F_T 0.15 to 0.45 (increments of 0.05) and .275, and the fully recruited fishing mortality as defined above for the oldest age group (15) in each year. The summary results of regression analysis between exploitable biomass calculated using average weights at age in Table 12b vs the standardized catch rates and fully recruited fishing mortality vs standardized effort are shown in table 14 and 15. Exploitable biomass was calculated by applying the partial recruitment vector (Table 13) to the total midyear biomass estimates derived from VPA (Table 16). Owing to the short time series, and the great variability in survey results, the research survey abundance indices could not be used for tuning the VPA. The relationships between exploitable biomass estimates from VPA at terminal $F_T = 0.275$ and standardized CPUE provided the regression line passing closest to the origin. Results of VPA at fully recruited $F = 0.275$ in the last year are shown in Table 16. The correlation coefficient had no discriminatory power for selecting F_T, because the distribution of observations (older year: low biomass, recent years high biomass levels) yielded essentially a 2-point regression.

The relationships between exploitable biomass and standardized catch rates, and fully recruited fishing mortality and standardized effort are shown in Figures 4 and 5.

7. CATCH PROJECTIONS

Catch projections were made using the populations numbers in 1983 from VPA at $F_T = 0.275$. Recruitment at age 4 in 1984 and 1985 was estimated as the geometric mean of recruitment from 1974 to 1980 (110×10^6 fish). The unusually large 1977 year class (age 4 in 1981) was excluded from the mean. The mean weights at age for 1984 and 1985 were estimated as the average of the mean weights between 1981 and 1983. Results of projections assuming $F_{0.1}$ (= 0.2) in 1984 and 1985 are shown in Table 17 while those assuming that the TAC for 1984 (100,000 t) will be taken and $F_{0.1}$ in 1985 are shown in Table 18. Under the latter set of assumptions, a catch of 90,000 t would result in 1985.

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Table 1: Historical monthly catch statistics for the 4RS 3Pn cod stock for the period 1961-1983. The pre-1961 data for 3Pn are too incomplete to allow monthly estimate for the stock as a whole.

MONTHS / YEARS	J	F	M	A	M	J	J	A	S	O	N	D	NK	TOTAL
1961*	364	12,375	44,543	8,745	1,473	5,761	14,341	6,752	2,490	1,408	1,305	453		100,010
1962*	316	12,903	24,720	4,656	1,565	6,951	16,717	11,738	3,513	1,535	1,016	291		85,921
1963*	649	7,661	13,336	2,478	1,623	17,419	14,870	10,698	3,104	1,916	692	300		74,746
1964	1,104	24,423	15,761	6,058	3,106	10,350	12,527	5,853	2,153	1,385	863	651		84,234
1965	792	12,506	21,171	3,698	2,216	5,267	10,422	5,945	3,636	1,359	927	990		68,929
1966	1,965	22,817	8,929	2,516	1,638	8,371	7,482	4,744	2,490	1,146	1,779	1,208		65,085
1967	7,872	7,028	14,792	8,447	2,017	7,525	12,664	5,232	7,154	3,315	1,356	1,909	1	79,312
1968	725	7,980	22,799	9,061	3,087	10,717	17,216	9,400	4,914	1,781	1,172	819		89,671
1969	875	4,654	9,675	4,220	5,192	10,958	12,103	8,639	7,866	3,557	2,035	1,366		71,140
1970	1,637	25,487	18,115	27,995	4,803	6,020	8,974	3,897	2,130	3,170	1,936	1,301		105,465
1971	845	44,590	7,580	5,250	2,338	5,839	8,420	3,039	2,374	1,616	1,004	915		83,810
1972	1,494	14,961	5,337	7,400	7,334	4,594	6,818	3,296	2,365	1,406	994	212	2,026	58,237
1973	16,472	10,556	7,586	4,826	3,235	5,860	5,125	4,145	2,365	1,459	1,016	567	2,593	65,805
1974	12,995	10,753	5,959	5,665	6,231	5,021	6,235	5,396	2,214	1,331	1,009	479	3,148	66,436
1975	8,232	19,486	2,702	2,616	5,316	5,122	5,042	4,488	2,767	1,267	819	704	1,672	60,233
1976	15,637	15,204	3,610	3,437	7,071	6,930	6,978	4,310	3,348	2,286	1,537	578	6,055	76,981
1977	11,143	8,603	3,790	11,312	10,057	7,368	8,133	5,780	3,361	1,751	1,814	454		73,566
1978	20,754	6,307	5,161	3,156	6,717	9,796	13,255	7,000	2,836	1,979	1,309	236		78,506
1979	15,543	4,273	6,475	6,647	8,517	12,890	12,085	8,660	2,971	2,449	1,816	451		82,777
1980	5,280	8,965	9,925	8,087	7,147	14,096	23,158	10,719	5,687	2,773	1,311	431		97,579
1981	9,156	15,368	3,170	3,763	12,835	17,257	16,344	10,343	5,676	2,550	1,172	277		97,911
1982	2,289	11,671	10,122	5,544	12,723	16,826	22,492	9,136	8,412	4,463	1,229	32		104,939
1983+	3,985	10,614	11,260	6,893	19,366	18,506	16,673	7,298	4,352	3,079	466	155		102,647

* Incomplete data. Some statistics reported for div. 3P only.

\+ Preliminary Statistics.

Table 2: Historical catch statistics for the 4RS 3Pn cod stock by division for the major participants involved in the fishery during the period 1954-1983.

3Pn

COUNTRIES / YEARS	CAN-N	CAN-M	CAN-Q	FR-M	FR-SPM	SPAIN	PORT.	OTHERS	TOTAL
1954									NK
1955									NK
1956									NK
1957									NK
1958									NK
1959*	4,901			651		59	1,162		6,773
1960*	5,181		2	3,694		1,428	976		11,281
1961*	5,728		42	8,515		15,551	8,282	100	38,218
1962*	8,022		3	3,807		9,310	3,506		24,648
1963*	8,076		65	2,148		5,764	4,139	12	20,204
1964	8,502			2,015		1,663	2,116	836	15,132
1965	8,344		2	5,206	277	1,466	1,009	431	16,735
1966	6,876		2	3,470	450	1,675	559	592	13,624
1967	4,546			6,622		2,512	1,273	5,475	20,428
1968	5,640			3,207	13	2,223	680	146	11,909
1969	4,763			47	5	102			4,917
1970	4,930			90	1	184			5,205
1971	6,661				26	167	990		7,844
1972	6,521			2,687	3	269	877		10,357
1973	5,885			1,008		515	3,841	51	11,300
1974	2,941		8	3,913	557	1,507	4,149	938	14,013
1975	2,758		18	2,612	295		538	12	6,233
1976	6,041		56	1,452	280			636	8,465
1977	7,109		247	167	42				7,565
1978	6,271		34	497					6,802
1979	10,208	151		557					10,916
1980	8,150	174		271	204				8,799
1981	11,191	60	3	2,869	1,006				15,130
1982	14,703	152	-	341	289	-	-	-	15,485
1983+	12,135	103	-	(4,211)		-	-	-	16,449

* Incomplete data. Some statistics reported from div. 3P only.

+ Preliminary Statistics.

Note: Subdivision 3Pn was created in 1959.

Can-N: Canada-Newfoundland; Can-M: Canada-Maritimes; Can-Q: Canada-Quebec; FR-M: France-Metropolitan; FR-SPM: France-St. Pierre and Miquelon; Port.: Portugal.

Table 2: continued

4R

COUNTRIES / YEARS	CAN-N	CAN-M	CAN-Q	FR-M	FR-SPM	SPAIN	PORT.	OTHERS	TOTAL
1954		16,571		14,050			1,598	7	32,226
1955	15,631	252		20,642		46	9,628	35	46,234
1956	15,635	4,076		10,568		14	8,737	32	39,062
1957	25,133	1,974		13,512			7,252	1	47,872
1958	18,832	7,139		30,037		314	15,334		71,656
1959	26,099	7,174		7,099		392	166		40,930
1960	17,302	5,937		21,970	4	7,331	13,418	604	66,566
1961	15,737	2,904		18,706		2,374	7,626		47,347
1962	21,984	3,482		7,043		5,451	10,142		48,102
1963	26,799	2,984		1,628		3,019	7,936		42,366
1964	20,162	3,197		16,264	38	6,806	12,492	1	58,960
1965	20,037	1,715		10,084	70	219	11,714		43,839
1966	21,202	1,813		9,735		1,097	10,361		44,208
1967	22,398	3,511		10,460	1	3,806	6,180	3,585	49,941
1968	32,810	4,415		22,963	169	2,779	6,905		70,041
1969	27,342	8,784		16,318	165	2,693	1,330		56,632
1970	23,337	11,337		30,303	120	8,053	17,993	3	91,146
1971	17,095	2,237		24,363	68	5,451	17,144	4	66,362
1972	11,664	3,348		10,608	3	1,357	8,144	2,459	37,583
1973	13,222	1,086		16,525	109	502	11,232	418	43,094
1974	16,348	5,538		11,679	395		5,302	184	39,446
1975	14,897	2,727		13,206	625		9,879	235	41,569
1976	20,004	6,648		15,392	918		9,034	4,034	56,030
1977	9,907	25,568		15,815	2,097				53,387
1978	35,376	6,290		13,252	2,022				56,940
1979	37,096	4,423	1,038	11,040	2,171				55,768
1980	52,358	2,822	582	8,275	646				64,683
1981	49,479	2,291	775	7,466	1,167				61,178
1982	51,248	2,024	882	9,875	1,458	-	-	-	65,487
1983+	55,538	3,270	2	(7,180)		-	-	-	65,990

+ Preliminary Statistics.

Table 2: continued

4S

COUNTRIES / YEARS	CAN-N	CAN-M	CAN-Q	FR-M	FR-SPM	SPAIN	PORT.	OTHERS	TOTAL
1954		2,928							2,928
1955	1	4,487		30			717		5,235
1956	11	2,318		319					2,648
1957	23	5,417		254			119		5,813
1958	157	7,597		38			20		7,812
1959	7	10,224				126			10,357
1960		16,057		18		428			16,503
1961	1	13,814		495		74	61		14,445
1962		13,171							13,171
1963	22	11,794					360		12,176
1964	45	10,077		18			2		10,142
1965	108	7,241					1,006		8,355
1966	88	6,777		57			331		7,253
1967	50	6,859		22			1,092	920	8,943
1968	146	7,558			17				7,721
1969	307	9,241			1	42			9,591
1970	443	8,175				198	298		9,114
1971	182	9,161			1	259		1	9,604
1972	189	9,130		27		338	613		10,297
1973	434	7,942					911	2,124	11,411
1974	366	8,976		86	4		1,474	2,077	12,983
1975	381	7,808		401	16		2,400	1,425	12,431
1976	726	9,231		22	23		1,099	1,385	12,486
1977	171	12,426		10	7				12,614
1978	229	14,535							14,764
1979	47	851	15,194		1				16,093
1980	1,437	1,417	21,243						24,097
1981	336	229	21,038						21,063
1982	141	1,386	22,390	50	-	-	-	-	23,967
1983+	356	1,328	18,524	-	-	-	-	-	20,208

+ Preliminary Statistics.

Table 2: continued

TOTAL

COUNTRIES / YEARS	CAN-N	CAN-M	CAN-Q	FR-M	FR-SPM	SPAIN	PORT.	OTHERS	TOTAL
1954									NK
1955									NK
1956									NK
1957									NK
1958									NK
1959*	31,007	17,398		7,750		577	1,328		58,060
1960*	22,483	21,996		25,682	4	9,187	14,394	604	94,350
1961*	21,466	16,760		27,716		17,999	15,969	100	100,010
1962*	30,006	16,656		10,850		14,761	13,648		85,921
1963*	34,897	14,843		3,776		8,783	12,435	12	74,746
1964	28,709	13,274		18,297	38	8,469	14,610	837	84,234
1965	28,489	8,958		15,290	347	1,685	13,729	431	68,929
1966	28,166	8,592		13,262	450	2,772	11,251	592	65,085
1967	26,994	10,370		17,104	1	6,318	8,545	9,980	79,312
1968	38,596	11,973		26,170	199	5,002	7,585	146	89,671
1969	32,412	18,025		16,365	171	2,837	1,330		71,140
1970	28,710	19,512		30,393	121	8,435	18,291	3	105,465
1971	23,938	11,398		24,363	95	5,877	18,134	5	83,810
1972	18,374	12,478		13,322	6	1,964	9,634	2,459	58,237
1973	19,541	9,028		17,533	109	1,017	15,984	2,593	65,805
1974	19,655	14,516		15,678	956	1,507	10,925	3,199	66,436
1975	18,036	10,553		16,219	936		12,817	1,672	60,233
1976	26,771	15,935		16,866	1,221		10,133	6,055	76,981
1977	17,187	38,241		15,992	2,146				73,566
1978	41,876	20,859		13,749	2,022				78,506
1979	47,351	5,425	16,232	11,597	2,172				82,777
1980	61,945	4,413	21,825	8,546	850				97,579
1981	61,006	2,580	21,816	10,335	2,173				97,911
1982	66,092	3,562	23,272	10,266	1,747	-	-	-	104,939
1983+	68,029	4,701	18,526	(11,391)		-	-	-	102,647

* Incomplete data. Some statistics reported for div. 3P only.

\+ Preliminary Statistics.

Note: Subdivision 3Pn was created in 1959. The total catch for this stock is unknown before then.

Table 3: Historical catch statistics for the 4RS 3Pn cod stock broken down into gear categories for the period 1954-1983. (DV, dory vessels; T, traps, GN, gillnets; HL, hand lines; LL long lines, IN misc, inshore, miscellaneous; DS, danish seines; PT, pair trawls; ST, shrimp trawls; OT, otter trawls.)

3Pn

GEARS / YEARS	DV	T	GN	HL	LL	IN. MISC.	DS	PT	ST	OT	TOTAL
1954											NK
1955											NK
1956											NK
1957											NK
1958											NK
1959*				1,016		3,885				1,872	6,773
1960*				1,246		3,934				6,101	11,281
1961*					2,083	3,645		15		32,475	38,218
1962*					2,988	5,005		29		16,626	24,648
1963*	53				3,062	4,922				12,167	20,204
1964	558				3,416	4,875		178		6,105	15,132
1965	113				2,702	4,815		142		8,963	16,735
1966	16				2,499	2,854		559		7,696	13,624
1967					657	3,463	27	33		16,248	20,428
1968	33				85	5,031	12	306		6,442	11,909
1969			444	270	3,630	39	10	24		500	4,917
1970		46	643	675	3,378		5	62		396	5,205
1971			364	217	5,574	134		52		1,503	7,844
1972	17	10	181	98	5,593	20	545	176		3,717	10,357
1973	1,405		175	110	5,431	97	174	356		3,552	11,300
1974	128		297	52	2,460	915	58	1,507		8,596	14,013
1975			61	152	2,418	12	6			3,584	6,233
1976		9	163	225	4,467	636	163			2,802	8,465
1977		37	73	163	5,679		119			1,494	7,565
1978		7	34	103	5,323		17			1,318	6,802
1979		25	40	116	7,338		181			3,216	10,916
1980			13	83	6,443		18			2,242	8,799
1981		4	3	72	7,560		28			7,463	15,130
1982		1	8	87	7,670		12			7,707	15,485
1983+		1	55	95	6,913		2	22		9,361	16,449

* Incomplete data. Some statistics reported for div. 3P only.

+ Preliminary Statistics.

Note: Subdivision 3 Pn was created in 1959.

Table 3: continued

4R

GEARS / YEARS	DV	T	GN	HL	LL	IN. MISC.	DS	PT	ST	OT	TOTAL
1954						16,413				15,813	32,226
1955	55					15,620				30,559	46,234
1956	3,057					15,316				20,689	39,062
1957	581			196		25,034				22,061	47,872
1958	2,619			2,261		18,075				48,701	71,656
1959	2,183			575		25,809				12,363	40,930
1960				108		17,135				49,323	66,566
1961					113	15,640	71			31,523	47,347
1962					104	21,486	105			26,407	48,102
1963					55	26,620	181			15,510	42,366
1964					123	18,789	185			39,863	58,960
1965					152	16,766	145		26,776		43,839
1966					201	15,532	53	38	28,384		44,208
1967					207	21,015	47		28,672		49,941
1968			289		1,138	26,130	60	508	41,916		70,041
1969		3,943	10,905	1,622	4,405	2,646	198	5	32,908		56,632
1970	184	2,340	4,319	1,673	5,489	1,962	239	225	5	74,710	91,146
1971		3,786	3,718	1,295	3,076	436	247		224	53,580	66,362
1972		1,606	2,835	1,107	1,115	2,851	16	24	168	27,861	37,583
1973		2,007	3,154	1,007	2,564	3,050	120	84	545	30,563	43,094
1974		1,789	5,182	1,714	1,358	666	223		28,514		39,446
1975		2,032	6,462	1,413	978	490	221		29,973		41,569
1976		1,572	7,671	1,445	527	4,238	155		40,422		56,030
1977		2,414	7,866	1,591	1,429	147	147		39,793		53,387
1978		4,103	13,235	1,749	2,462		233		35,158		56,940
1979		3,071	11,479	3,138	5,031		311		32,738		55,768
1980		8,354	11,607	2,380	7,768		467		34,107		64,683
1981		5,408	5,796	2,096	8,936	327	384		38,231		61,178
1982		7,473	9,465	2,126	7,208		337		38,878		65,487
1983+		3,333	11,774	5,052	6,517		421		38,893		65,990

+ Preliminary Statistics.

Table 3: continued

4S

GEARS / YEARS	DV	T	GN	HL	LL	IN. MISC.	DS	PT	ST	OT	TOTAL
1954						2,892				36	2,928
1955						4,423				812	5,235
1956						2,197				451	2,648
1957						5,217				596	5,813
1958				107		7,114				591	7,812
1959				434		9,368				555	10,357
1960				5,159		2,037				9,307	16,503
1961		1,133			2,229	3,830	5			7,248	14,445
1962		2,777	80	3,974	2,057		24			4,259	13,171
1963		3,197		3,570	432		15			4,962	12,176
1964					486	6,166				3,490	10,142
1965		3,950	24		320		1		4,060		8,355
1966		1,656	973		441	798			3,385		7,253
1967		2,470	1,618	710	305				3,840		8,943
1968		3,070	1,127	623	333				2,568		7,721
1969		2,312	1,960	607	262				4,450		9,591
1970	21	1,789	846	771	251				215	5,221	9,114
1971		2,410	963	503	565			1	309	4,853	9,604
1972		2,040	1,418	511	511				242	5,575	10,297
1973		885	1,774	470	402	2,248			477	5,155	11,411
1974		200	2,326	402	976	2,064			7,009		12,977
1975		579	2,072	2,337	136	1,425			5,882		12,431
1976		992	2,900	353	46	1,385			6,810		12,486
1977		861	4,089	303	36		2		7,323		12,614
1978		2,178	3,626	194	28		2		8,736		14,764
1979		1,043	6,578	467	148				7,857		16,093
1980			1,376		1,796	11,658			9,267		24,097
1981		3	364		2,678	12,554		51	5,953		21,603
1982		13	27	-	3,688	11,629	3	340	8,267		23,967
1983+		5,769	5,095	228	581		174		8,361		20,208

+ Preliminary Statistics.

Table 3: continued

TOTAL

GEARS / YEARS	DV	T	GN	HL	LL	IN. MISC.	DS	PT	ST	OT	GRAND TOTAL
1954											NK
1955											NK
1956											NK
1957											NK
1958											NK
1959*											NK
1960*				6,513		23,106				64,731	94,350
1961*		1,133			4,425	23,115	76	15		71,246	100,010
1962*		2,777	80	3,974	5,149	26,491	129	29		47,292	85,921
1963*	53	3,197		3,570	3,549	31,542	196			32,639	74,746
1964	558				4,025	29,830	185	178		49,458	84,234
1965	113	3,950	24		3,174	21,581	146	142	39,799		68,929
1966	16	1,656	973		3,141	19,184	53	597	39,465		65,085
1967		2,470	1,618	710	1,169	24,478	74	33	48,760		79,312
1968	33	3,070	1,416	623	1,556	31,161	72	814	50,926		89,671
1969		6,255	13,309	2,499	8,297	2,685	208	29	37,858		71,140
1970	205	4,175	5,808	3,119	9,118	1,962	244	287	220	80,327	105,465
1971		6,196	5,045	2,015	9,215	570	247	53	533	59,936	83,810
1972	17	3,656	4,434	1,716	7,219	2,871	561	200	410	37,153	58,237
1973	1,405	2,892	5,103	1,587	8,397	5,395	294	440	1,022	39,270	65,805
1974	128	1,989	7,805	2,168	4,794	3,645	281	1,507	44,119		66,436
1975		2,611	8,595	3,902	3,532	1,927	227		39,439		60,233
1976		2,573	10,734	2,023	5,040	6,259	318		50,034		76,981
1977		3,312	12,028	2,057	7,144	147	268		48,610		73,566
1978		6,288	16,895	2,046	7,813		252		45,212		78,506
1979		4,139	18,097	3,721	12,517		492		43,811		82,777
1980		8,354	12,996	2,463	16,007	11,658	485		45,616		97,579
1981		5,415	6,163	2,168	19,174	12,881	463		51,647		97,911
1982		7,487	9,500	2,213	18,566	11,629	352	340	54,852		104,939
1983+		9,103	16,924	5,375	14,011		597	22	56,615		102,647

+ Preliminary Statistics.

Note: Subdivision 3Pn was created in 1959. The total for the stock is unknown before then.

Table 4. Preliminary catch statistics for cod in NAFO Division 3Pn in 1983.

Division 3Pn

CANADA-NEWFOUNDLAND

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Traps	0	0	0	0	0	0	0	1	0	0	0	0	1
Fixed gillnets	0	0	0	0	3	28	13	10	0	1	0	0	55
Handlines	12	2	1	1	2	34	17	22	2	1	1	0	95
Lines trawls	1443	1074	1722	530	409	401	135	264	381	554	0	0	6913
Danish seines	0	0	0	0	0	2	0	0	0	0	0	0	2
Otter trawls	145	1944	2763	148	0	2	3	3	32	5	1	1	5047
Pair trawls	0	13	9	0	0	0	0	0	0	0	0	0	22
Total	1600	3033	4495	679	414	467	168	300	415	561	2	1	12135

CANADA-MARITIME

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Otter trawls	0	103	0	0	0	0	0	0	0	0	0	0	103
Total	0	103	0	0	0	0	0	0	0	0	0	0	103

FRANCE (M + SP)

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Otter trawls	529	3534	148	0	0	0	0	0	0	0	0	0	4211
Total	529	3534	148	0	0	0	0	0	0	0	0	0	4211

DIVISION TOTAL	2129	6670	4643	679	414	467	168	300	415	561	2	1	16449

Table 4. Continued. Preliminary catch statistics for cod in NAFO Division 4R in 1983.

Division 4R

CANADA-NEWFOUNDLAND

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Traps	0	0	0	1	76	2428	736	84	8	0	0	0	3333
Fixed gillnets	4	0	3	1105	1617	2735	4219	1209	445	418	19	0	11774
Handlines	16	29	30	48	93	507	1033	1870	1121	255	35	15	5052
Lines trawls	137	363	470	946	1176	1362	579	647	566	230	4	0	6480
Danish seines	0	0	0	37	47	155	45	53	49	34	1	0	421
Otter trawls	333	1965	2320	2272	11360	4846	4198	227	471	396	55	35	28478
Total	490	2357	2823	4409	14369	12033	10810	4090	2660	1333	114	50	55538

CANADA-MARITIME

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Lines trawls	0	0	0	0	0	31	0	0	0	0	0	0	31
Otter trawls	127	13	32	877	2019	135	1	16	0	4	4	11	3239
Total	127	13	32	877	2019	166	1	16	0	4	4	11	3270

CANADA-QUEBEC

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Otter trawls	0	0	0	0	0	1	0	0	0	1	0	0	2
Total	0	0	0	0	0	1	0	0	0	1	0	0	2

FRANCE (M + SP)

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Otter trawls	1207	1570	3669	734	0	0	0	0	0	0	0	0	7180
Total	1207	1570	3669	734	0	0	0	0	0	0	0	0	7180

DIVISION TOTAL	1824	3940	6524	6020	16388	12200	10811	4106	2660	1338	118	61	65990

Table 4. Continued. Preliminary catch statistics for cod in NAFO Division 4S in 1983.

Division 4S

CANADA-NEWFOUNDLAND

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Fixed gillnets	0	0	0	0	0	54	283	0	0	0	0	0	337
Handlines	0	0	0	0	0	0	0	2	0	0	0	0	2
Otter trawls	2	0	0	3	0	12	0	0	0	0	0	0	17
Total	2	0	0	3	0	66	283	2	0	0	0	0	356

CANADA-MARITIME

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Otter trawls	30	4	1	7	36	59	31	154	241	270	228	93	1154
Danish seines	0	0	0	0	143	0	0	0	20	11	0	0	174
Total	30	4	1	7	179	59	31	154	261	281	228	93	1328

CANADA-QUEBEC

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Traps	0	0	0	0	278	2401	2972	118	0	0	0	0	5769
Fixed gillnets	0	0	92	0	131	1565	1223	1483	254	10	0	0	4758
Handlines	0	0	0	0	0	224	0	2	0	0	0	0	226
Lines trawls	0	0	0	25	320	59	108	36	19	14	0	0	581
Otter trawls	0	0	0	159	1656	1465	1077	1097	743	875	118	0	7190
Total	0	0	92	184	2385	5714	5380	2736	1016	899	118	0	18524

DIVISION TOTAL	32	4	93	194	2564	5839	5694	2892	1277	1180	346	93	20208

Table 4. Continued. Preliminary catch statistics for cod in NAFO Division 3Pn, 4RS in 1983.

CANADA-NEWFOUNDLAND

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Traps	0	0	0	1	76	2428	736	85	8	0	0	0	3334
Fixed gillnets	4	0	3	1105	1620	2817	4515	1219	445	419	19	0	12166
Handlines	28	31	31	49	95	541	1050	1894	1123	256	36	15	5149
Line trawls	1580	1437	2192	1476	1585	1763	714	911	947	784	4	0	13393
Danish seines	0	0	0	37	47	157	45	53	49	34	1	0	423
Otter trawls	480	3909	5083	2423	11360	4860	4201	230	503	401	56	36	33542
Pair trawls	0	13	9	0	0	0	0	0	0	0	0	0	22
Total	2092	5390	7318	5091	14783	12566	11261	4392	3075	1894	116	51	68029

CANADA-MARITIME

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Line trawls	0	0	0	0	0	31	0	0	0	0	0	0	31
Danish seines	0	0	0	0	143	0	0	0	20	11	0	0	174
Otter trawls	157	120	33	884	2055	194	32	170	241	274	232	104	4496
Total	157	120	33	884	2198	225	32	170	261	285	232	104	4701

CANADA-QUEBEC

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Traps	0	0	0	0	278	2401	2972	118	0	0	0	0	5769
Fixed gillnets	0	0	92	0	131	1565	1223	1483	254	10	0	0	4758
Handlines	0	0	0	0	0	224	0	2	0	0	0	0	226
Lines trawls	0	0	0	25	320	59	108	36	19	14	0	0	581
Otter trawls	0	0	0	159	1656	1466	1077	1097	743	876	118	0	7192
Total	0	0	92	184	2385	5715	5380	2736	1016	900	118	0	18526

FRANCE (M + SP)

Gear type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Otter trawls	1736	5104	3817	734	0	0	0	0	0	0	0	0	11391
Total	1736	5104	3817	734	0	0	0	0	0	0	0	0	11391

DIVISION TOTAL	3985	10614	11260	6893	19366	18506	16673	7298	4352	3079	466	155	102647

Table 5. Results of the ANOVA from the regression of ln catch rates against dummy categorical variables in NAFO Divisions 4R, 4S and 3Pn. For type definitions, see table 6.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.888
MULTIPLE R SQUARED.....0.789

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	8.856E1	8.856E1	
REGRESSION	36	6.817E2	1.894E1	96.323
TYPE 1	8	1.578E2	1.972E1	100.322
TYPE 2	4	6.545E1	1.636E1	83.227
TYPE 3	1	2.765E1	2.765E1	140.631
TYPE 4	23	6.275E1	2.728E0	13.878
RESIDUALS	926	1.821E2	1.966E-1	
TOTAL	963	9.524E2		

Table 6. Regression coefficients for grouped categories from the Multiplicative model (Gavaris, 1980) applied to catch rates of cod from NAFO divisions 4R, 4S and 3Pn.

Type	Variable	Ln-power	Standard error	Number/ observations
INTERCEPT		-0.070	0.127	963
1) Country-Gear[1]	Can-M: OT-4 + Can-Q: OT-4	0.000	0.000	108
	Can-M: OT-5	0.347	0.060	105
	Can-N: OT-4	-0.220	0.053	191
	Can-N: OT-5	0.092	0.067	82
	Can-Q: OT-2	-1.340	0.078	51
	Can-Q: OT-3	-0.917	0.074	73
	Spain: PT-4	0.708	0.132	26
	Port : OT-6 + Spain: OT-6	0.632	0.058	226
	Port : OT-7	0.930	0.087	41
2) Months	January + February	0.000	0.000	264
	March	-0.174	0.049	139
	April + May	-0.325	0.042	264
	June + July	-0.541	0.060	102
	August to December	-0.623	0.053	194
3) Divisions	3Pn + 4S	0.000	0.000	435
	4R	0.193	0.036	528
4) Years	See Table 7			

1 CAN-M: Canada-Maritimes; CAN-N: Canada-Newfoundland; CAN-Q: Canada-Québec;
PORT: Portugal
OT: Otter trawl; PT: Pair trawl followed by tonnage class.

Table 7. Mean catch rate indices for cod in NAFO Divisions 4RS 3Pn, standardized to Can-M /OT 4 / January-February / 3Pn-4S with standard errors. The proportion (PROP.) of the total catch that was used to compute catch rates is also indicated.

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 0 0 0

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1960	94350	0.251	1.020	0.129	92489
1961	100010	0.363	1.320	0.143	75754
1962	85921	0.335	1.311	0.152	65517
1963	74746	0.283	1.572	0.195	47534
1964	84234	0.282	1.439	0.173	58529
1965	68929	0.276	1.220	0.124	56518
1966	65085	0.312	1.118	0.109	58208
1967	79312	0.237	0.969	0.084	81840
1968	89671	0.235	1.131	0.099	79273
1969	71140	0.203	0.999	0.088	71187
1970	105465	0.397	0.944	0.076	111677
1971	83810	0.353	0.667	0.062	125614
1972	58237	0.301	0.753	0.070	77381
1973	65805	0.262	0.655	0.065	100455
1974	66436	0.303	0.959	0.081	69247
1975	60233	0.267	0.743	0.067	81082
1976	76981	0.142	0.728	0.058	105807
1977	73566	0.273	0.755	0.058	97464
1978	78506	0.208	0.817	0.066	96039
1979	82777	0.158	0.916	0.082	90363
1980	97579	0.119	0.930	0.071	104980
1981	97911	0.077	1.417	0.139	69082
1982	104916	0.080	1.871	0.171	56066
1983	102647	0.060	1.668	0.184	61522

AVERAGE C.V. FOR THE MEAN:0.096

Table 8. Cod biomass estimates (t) from research surveys in NAFO Divisions 3Pn, 4R, 4S.

Strata	Gadus 4* 1978	Gadus 16* 1979	Gadus 31* 1980	Gadus 46** 1981	Gadus 73 1983	Gadus 89 1984
301	-	-	-	-	-	-
302	8,880	1,073	3,036	5,063	4,341	2,655
303	2,459	96	2,786	1,536	3,872	2,483
304	127	108	639	355	1,867	52
305	271	170	508	5,518	337	80
Total 3Pn	11,737	1,447	6,969	12,471	10,417	5,270
801	127	1,299	126	66	2,208	2,737
802	1,863	646	10,523	2,112	308	395
809	3,512	4,524	1,924	4,156	1,787	2,420
810	1,811	583	8,889	3,515	1,360	1,080
811	8,195	3,686	20,412	31,536	6,996	76,745
812	16,047	7,435	882	1,068	8,269	35,884
813	7,459	541	1,575	267	25,546	21,197
820	5,162	4,022	103,645	45,384	3,171	3,668
821	59,500	2,943	5,082	6,329	4,361	12,866
822	59,876	37,986	224	312	16,539	35,165
823	8,356	283	29	-	774	10,630
824	0	2	2	-	6,931	31
Total 4R	171,908	63,950	153,313	94,745	78,250	202,818
803	1,594	-	18,567	6,871	1,066	2,443
804	515	-	1,035	2,035	506	818
825	-	-	273	189	-	-
806	299	-	163	35	144	-
807	856	278	180	227	5,026	322
808	5,171	4,557	8,844	9,779	8,195	24,155
814	535	-	95	92	23,967	10,809
815	1,007	1,276	1,109	495	30,452	77,504
816	1,160	5,899	1,195	101	10,949	804
817	-	-	88	30	175	-
818	140	-	986	44	4,034	-
819	312	2,655	79	24	11,949	9,641
825	433	-	49	-	26,900	-
826	-	-	-	-	54	-
827	127	-	9	35	11,321	276
828	200	-	85	9	5	-
829	294	14,399	18	37	2,799	53
830	210	-	60	70	16,059	29
831	3	-	1	4	-	-
832	-	-	21	11	87	-
833	124	-	-	-	918	2,622
834	< 1	-	< 1	2	-	-
Total 4S	12,980	29,064	32,857	20,090	154,606	129,476
Total 3Pn 4RS	196,625	94,461	193,139	127,307	243,273	337,564

* Bishop (1980)
** C. Bishop personal communication

Table 9. Commercial sampling for 4RS, 3Pn cod in 1983.

Gear	Quarter	Country	Division	Lenght measurements	Otoliths
A) Mobile					
OTB[1]	1	CAN(N)	3Pn	2125	267
		CAN(N	4R	2170	123
		FRA(SPM)	3Pn	8620	-
			4R	14731	-
	2	CAN(M)	4R	958	73
		CAN(N)	3Pn	1728	25
			4R	5199	415
		FRA(SPM)	3Pn	421	-
			4R	10288	-
	3	CAN(Q)	4S	804	123
		CAN(N)	4R	711	-
	4	CAN(M)	4R	531	-
		CAN(Q)	4S	165	142
		CAN(N)	4R	4469	339
ST[2]	2	CAN(M)	4R	128	48
	3	CAN(M)	4S	106	29
		CAN(Q)	4S	1470	203
	4	CAN(M)	4S	228	49
		CAN(Q)	4S	473	-

1 Otter trawlers
2 Shrimp trawlers

Table 9. (continued)

Gear	Quarter	Country	Division	Lenght measurements	Otoliths
B) Fixed					
LLS[1]	1	CAN(N)	3Pn	2526	306
		CAN(N)	4R	583	267
	2	CAN(N)	3Pn	1083	411
			4R	740	163
	3	CAN(Q)	4S	24	13
		CAN(N)	3Pn	1355	173
			4R	1514	200
	4	CAN(Q)	4S	324	105
		CAN(N)	3Pn	490	70
			4R	204	36
GN[2]	2	CAN(Q)	4S	78	-
	3	CAN(Q)	4S	1994	24
		CAN(N)	4R	2925	205
	4	CAN(N)	4R	2527	88
LH[3]	3	CAN(Q)	4S	178	118
		CAN(N)	4R	408	55
	4	CAN(Q)	4S	400	-
		CAN(N)	4R	448	50
FIX[4]	4	CAN(N)	4R	558	63

1 Long lines
2 Gillnets
3 Handlines
4 Traps

Table 10. Quarterly catch at age and average weight at age of cod for inshore gears and otter trawl in NAFO Divisions 4R, 4S and 3Pn in 1983.

	INSHORE (ALL GEARS)								OTTER TRAWLS							
QUARTER	1		2		3		4		1		2		3		4	
AGE	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$
2													11	0.10		
3	13	0.44	1	0.34	25	0.44	16	0.57					140	0.37	4	0.69
4	96	0.72	109	1.25	724	0.84	105	0.82	93	0.80	67	0.69	436	0.87	71	1.11
5	397	1.03	1 269	1.24	2 127	1.32	205	1.35	1 641	1.15	1 316	1.13	1 882	1.40	224	1.35
6	707	1.39	2 282	1.74	3 204	1.92	851	1.73	5 609	1.39	6 690	1.43	1 295	1.74	492	1.75
7	465	1.79	1 961	1.83	2 150	2.42	145	2.34	2 829	1.65	2 789	1.72	781	1.92	242	2.06
8	381	2.12	1 309	2.13	1 027	2.77	49	2.71	1 952	1.84	2 238	1.99	461	2.32	94	2.22
9	333	2.56	1 053	2.76	443	3.60	35	3.01	844	2.11	1 427	2.10	155	2.47	16	2.66
10	154	3.34	570	3.06	160	3.99	13	4.03	189	2.38	520	3.01	29	3.26	19	7.44
11	111	4.15	210	3.93	57	4.93	13	3.35	44	2.76	261	3.92	40	2.28		
12	19	3.94	137	3.98	19	7.67	5	7.65	8	3.83	19	3.93				
13	16	5.78	96	3.89	7	10.71	1	9.93	3	14.21	8	5.59			2	3.49
14	7	4.57	15	8.18				7.62								
15	4	8.62	10	9.23			1	5.63			9	11.05			1	5.59
16	2	9.44			5	5.59	1	5.08								
17	5	4.46	3	5.59												
18			1	17.93			1	3.95								
NO AGED	573		574		920		442		390		545		355		593	

Table 11. Catch at age and average weights of cod in NAFO division 4R, 4S and 3Pn in 1983.

AGE	CATCH IN 1 000's	AVERAGE WEIGHT
2	11	0.10
3	199	0.41
4	1 701	0.88
5	9 061	1.26
6	21 130	1.58
7	11 362	1.91
8	7 561*	2.14
9	4 306	2.51
10	1 654	3.16
11	744	3.90
12	207	3.62
13	133	4.63
14	22	7.26
15	25	9.48
16	8	6.43
17	8	4.98
18	2	12.80

* An addition error was found in computing the total catch at age for age 11. 7180 x 10^3 fish were used in cohort analysis. VPA with this correct value at age 8 produces a 4+ total biomass of 641,000 t instead of 636 000 t.

Table 12a. Catch at age ($\times 10^{-3}$) matrix used in sequential population analysis.

b. Mean weights at age for cod in NAFO Divisions 4RS 3Pn.

4RS 3PN COD: CATCH AT AGE 24/ 7/84

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4 I	1471	2924	1984	3141	3134	4110	2620	13173	4551	1701
5 I	5121	4380	14724	10292	11159	16209	15975	10711	21302	9601
6 I	11537	6446	7570	15321	17601	13751	20475	21606	13283	21130
7 I	7353	9048	3775	7653	10346	12890	10821	14094	13130	11362
8 I	10987	3392	5867	2882	2432	4669	6029	5088	7624	7180
9 I	3902	5808	2016	3041	1164	1416	1262	1988	2940	4306
10 I	2722	1647	2584	949	1188	643	398	682	1649	1654
11 I	704	815	1717	612	460	473	217	162	539	744
12 I	273	870	600	292	382	252	268	98	186	207
13 I	147	64	196	171	194	112	68	76	117	133
14 I	48	52	90	49	106	83	88	42	93	22
15 I	40	150	27	11	17	28	24	37	29	25

4RS 3PN COD: AVERAGE WEIGHTS (KG) AT AGE 24/ 7/84

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4 I	0.57	0.57	0.57	0.57	0.68	0.55	0.52	0.72	0.83	0.88
5 I	0.86	0.86	0.86	0.86	0.87	0.89	0.82	0.96	1.07	1.26
6 I	1.30	1.30	1.30	1.30	1.30	1.32	1.29	1.31	1.39	1.58
7 I	1.79	1.79	1.79	1.79	1.84	1.78	1.76	1.78	1.72	1.91
8 I	2.43	2.43	2.43	2.43	2.56	2.41	2.37	2.22	2.16	2.14
9 I	3.06	3.06	3.06	3.06	3.01	3.15	3.42	2.76	2.83	2.51
10 I	3.60	3.60	3.60	3.60	2.88	3.57	4.17	3.96	3.87	3.16
11 I	4.06	4.06	4.06	4.06	3.23	3.79	4.43	5.33	5.26	3.90
12 I	4.48	4.48	4.48	4.48	3.96	4.51	3.78	6.97	6.90	3.62
13 I	4.89	4.89	4.89	4.89	4.12	5.23	4.98	6.20	6.86	4.63
14 I	5.30	5.30	5.30	5.30	5.84	4.74	3.93	7.80	6.62	7.26
15 I	5.71	5.71	5.71	5.71	9.33	5.43	7.00	3.91	6.67	9.48

Table 13a. F ratios table ($F/\overline{F}_{(7-11)}$) for cod in NAFO Divisions 4RS 3Pn.

b. Partial recruitments estimated as the average of historical partial recruitments (i.e. ratios) from 1974 to 1980 (age 7^{+}, PR = 1).

4RS-3PN COD: F RATIOS 24/ 7/84

	I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4	I	0.056	0.071	0.037	0.051	0.039	0.055	0.056	0.185	0.105	0.053
5	I	0.330	0.249	0.463	0.217	0.274	0.291	0.376	0.368	0.414	0.320
6	I	0.565	0.747	0.608	0.702	0.646	0.553	0.734	0.961	0.676	0.651
7	I	0.902	0.880	0.729	1.019	1.084	0.950	0.974	1.039	1.002	1.000
8	I	1.052	0.928	1.068	0.933	0.766	1.189	1.149	0.985	0.974	1.000
9	I	0.914	1.458	1.039	1.064	0.892	0.924	0.844	0.827	0.978	1.000
10	I	1.303	0.847	1.620	0.888	1.081	1.107	0.604	0.948	1.179	1.000
11	I	0.698	1.005	2.029	0.817	1.040	1.000	0.982	0.452	1.346	1.000
12	I	1.378	2.496	1.629	0.843	1.269	1.444	1.611	0.950	0.793	1.000
13	I	1.477	0.817	2.138	1.058	1.479	0.898	1.169	1.158	2.323	1.000
14	I	0.334	1.626	3.484	1.689	2.197	2.142	2.118	1.825	3.484	1.000
15	I	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

4RS 3PN COD: PARTIAL RECRUITMENTS 24/ 7/84

AGES	4	5	6	7	8	9	10	11	12	13	14	15
I	0.052	0.314	0.651	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 14. Results of the regression analysis between CPUE and exploitable biomass estimated from VPA (1983 excluded from the regression).

1/ 6/84

SUMMARY TABLE; 1983 EXCLUDED

TERMINAL F:		0.150		0.200		0.250		0.275		0.300	
R:		9.756E-1		9.756E-1		9.730E-1		9.700E-1		9.672E-1	
INTERCEPT:		-1.142E5		-4.687E4		-6.458E3		3.434E3		2.048E4	
SLOPE		3.376E5		2.434E5		1.869E5		1.684E5		1.492E5	
YEAR	IND.	OB.	PR.	OB.	PR.	OB.	PR.	OB.	PR.	OB.	PR.
1974	0.959	166215	209552	165052	186548	164353	172735	159495	164968	163886	163524
1975	0.743	139295	136625	137531	133974	136471	132374	131806	128585	135765	131306
1976	0.728	122463	131560	119610	130323	117893	129572	113942	126059	116748	129069
1977	0.755	128052	140676	122773	136895	119598	134617	115544	130607	117481	133096
1978	0.817	152445	161609	142171	151985	135995	146202	131459	141050	131876	142344
1979	0.916	200214	195034	179840	176082	167595	164700	160978	157725	159424	157110
1980	0.930	266747	199761	229808	179490	207624	167316	197959	160084	192827	159198
1981	1.417	370074	364184	304637	298025	265355	258314	249556	242114	239167	231836
1982	1.871	510959	517465	400427	408528	334091	343145	309037	318585	289862	299553
1983	1.688	698296	455680	523722	363986	418977	308951	380352	287761	349147	272257

1/ 6/84

SUMMARY TABLE ; 1983 EXCLUDED

TERMINAL F:		0.350		0.400		0.450		0.500	
R:		9.575E-1		9.433E-1		9.238E-1		8.986E-1	
INTERCEPT:		3.973E4		5.415E4		6.536E4		7.432E4	
SLOPE		1.222E5		1.020E5		8.636E4		7.383E4	
YEAR	IND.	OB.	PR.	OB.	PR.	OB.	PR.	OB.	PR.
1974	0.959	163553	156945	163305	152015	163108	148184	162954	145124
1975	0.743	135261	130543	134882	129972	134586	129530	134352	129176
1976	0.728	115927	128710	115317	128441	114842	128234	114460	128069
1977	0.755	115968	132010	114832	131197	113953	130566	113249	130062
1978	0.817	128935	139588	126730	137524	125017	135920	123649	134640
1979	0.916	153590	151689	149215	147627	145819	144470	143106	141949
1980	0.930	182260	153401	174341	149055	168190	145680	163277	142983
1981	1.417	220465	212927	206453	198753	195568	187739	186872	178938
1982	1.871	258274	268420	234593	245083	216187	226948	201479	212457
1983	1.688	299268	246051	261061	226408	232765	211143	209488	198946

Table 15. Results of the regression analysis between standardized effort and fully recruited fishing mortality estimated from VPA (1983 excluded from the regression).

SUMMARY TABLE ; 1983 EXCLUDED 1/ 6/84

TERMINAL F:		0.150		0.200		0.250		0.275		0.300		0.350	
R:		4.904E-1		5.217E-1		5.388E-1		5.369E-1		5.454E-1		5.429E-1	
INTERCEPT:		7.566E-2		1.185E-1		1.632E-1		1.837E-1		2.072E-1		2.491E-1	
SLOPE:		3.944E-6		3.784E-6		3.519E-6		3.457E-6		3.212E-6		2.892E-6	
YEAR	IND.	OB.	PR.	OB.	PR.	OB.	PR.	OB.	PR.	OB.	PR.	OB.	PR.
1974	69247	0.541	0.349	0.545	0.380	0.547	0.407	0.560	0.423	0.549	0.430	0.550	0.449
1975	81082	0.476	0.395	0.482	0.425	0.485	0.449	0.499	0.464	0.487	0.468	0.489	0.484
1976	105807	0.503	0.493	0.513	0.519	0.518	0.536	0.535	0.549	0.522	0.547	0.525	0.555
1977	97464	0.567	0.460	0.593	0.487	0.610	0.506	0.627	0.521	0.622	0.520	0.630	0.531
1978	96039	0.496	0.454	0.527	0.482	0.548	0.501	0.560	0.516	0.563	0.516	0.574	0.527
1979	90363	0.431	0.432	0.475	0.460	0.506	0.481	0.518	0.496	0.529	0.497	0.547	0.510
1980	104980	0.297	0.490	0.343	0.516	0.378	0.533	0.393	0.547	0.406	0.544	0.429	0.553
1981	69082	0.218	0.348	0.263	0.380	0.301	0.406	0.317	0.423	0.333	0.429	0.360	0.449
1982	56066	0.189	0.297	0.240	0.331	0.285	0.361	0.307	0.378	0.327	0.387	0.365	0.411
1983	61522	0.150	0.318	0.200	0.351	0.250	0.380	0.275	0.396	0.300	0.405	0.350	0.427

SUMMARY TABLE ; 1983 EXCLUDED 1/ 6/84

TERMINAL F:		0.400		0.450		0.500	
R:		5.315E-1		5.105E-1		4.798E-1	
INTERCEPT:		2.888E-1		3.260E-1		3.608E-1	
SLOPE:		2.572E-6		2.261E-6		1.962E-6	
YEAR	IND.	OB.	PR.	OB.	PR.	OB.	PR.
1974	69247	0.551	0.467	0.552	0.483	0.552	0.497
1975	81082	0.490	0.497	0.491	0.509	0.492	0.520
1976	105807	0.528	0.561	0.529	0.565	0.531	0.568
1977	97464	0.637	0.539	0.642	0.546	0.647	0.552
1978	96039	0.582	0.536	0.589	0.543	0.595	0.549
1979	90363	0.561	0.521	0.572	0.530	0.582	0.538
1980	104980	0.448	0.559	0.464	0.563	0.477	0.567
1981	69082	0.383	0.466	0.403	0.482	0.421	0.496
1982	56066	0.401	0.433	0.433	0.453	0.463	0.471
1983	61522	0.400	0.447	0.450	0.465	0.500	0.482

Table 16. Results of VPA for cod in NAFO Divisions 4RS 3Pn at F_T = 0.275 and with a partial recruitment as in table 13b: Above: Numbers at age; Below midyear mean biomass.

VPA ; COD OF 4 RS, 3Pn : POPULATION NUMBERS 1/ 6/84

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4 I	52136	93291	110946	108895	159063	160649	133658	254715	158385	129675
5 I	33389	41358	73741	89043	86320	127400	127818	107064	196655	125566
6 I	46746	22725	29912	47128	63626	60618	89701	90253	78000	141806
7 I	20296	27905	12819	17689	24845	36288	37267	55034	54474	51903
8 I	26976	10030	14733	7107	7641	11089	18161	20799	32396	32799
9 I	10667	12257	5171	6812	3240	4075	4903	9463	12456	19670
10 I	5731	5238	4851	2429	2860	1610	2067	2881	5960	7556
11 I	2386	2263	2811	1670	1139	1279	743	1334	1746	3399
12 I	553	1322	1122	777	819	521	624	413	946	946
13 I	285	210	312	385	375	330	202	271	250	608
14 I	310	102	114	81	162	134	169	104	154	100
15 I	54	210	37	15	23	39	36	60	48	43
4+I	199530	216911	256569	282031	350116	404033	415349	542392	541470	514071
5+I	147394	123619	145623	173136	191052	243383	281691	287676	383084	384395
6+I	114005	82262	71882	84092	104732	115983	153873	180613	186429	258829
7+I	67258	59537	41970	36965	41106	55365	64173	90360	108429	117023

VPA; COD OF 4RS, 3Pn : MIDYEAR BIOMASS 1/ 6/84

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4 I	26527	47386	56768	55387	97000	78985	62332	161593	116607	102702
5 I	23836	30381	51122	65037	63261	95631	88518	88095	178642	137469
6 I	47475	22492	30248	45247	63290	63360	91540	92832	88862	186485
7 I	26071	36914	17334	21427	31376	46613	49697	76041	73400	78914
8 I	45341	17822	24951	11963	14521	18268	31622	36125	54966	55873
9 I	23358	24449	11105	13934	7016	9319	13006	20912	27751	39302
10 I	13436	14038	10739	6134	5658	4002	6981	8973	17629	19006
11 I	7315	6603	6424	4850	2553	3458	2490	6019	6868	10551
12 I	1587	3132	3086	2473	2129	1519	1599	2266	5275	2725
13 I	870	768	838	1259	965	1259	736	1282	1126	2239
14 I	1360	340	256	245	504	355	415	566	576	581
15 I	217	864	150	56	151	150	191	184	251	326
4+I	217394	205190	213023	228013	288425	322918	349128	494889	571952	636173
5+I	190866	157804	156254	172626	191425	243933	286796	333296	455346	533471
6+I	167031	127424	105132	107589	128164	148302	198279	245201	276704	396002
7+I	119555	104931	74884	62341	64874	84942	106738	152368	187842	209518

Table 16. Continued: Fishing mortalities.

VPA ; COD OF 4RS , 3Pn : FISHING MORTALITY 1/ 6/84

	I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
4	I	0.032	0.035	0.020	0.032	0.022	0.029	0.022	0.059	0.032	0.015
5	I	0.185	0.124	0.248	0.136	0.153	0.151	0.148	0.117	0.127	0.088
6	I	0.316	0.373	0.325	0.440	0.362	0.286	0.289	0.305	0.207	0.179
7	I	0.505	0.439	0.390	0.639	0.607	0.492	0.383	0.330	0.307	0.275
8	I	0.589	0.462	0.571	0.585	0.429	0.616	0.452	0.313	0.299	0.275
9	I	0.511	0.727	0.556	0.668	0.499	0.479	0.332	0.262	0.300	0.275
10	I	0.729	0.422	0.866	0.557	0.605	0.574	0.238	0.301	0.362	0.275
11	I	0.391	0.501	1.085	0.512	0.582	0.518	0.386	0.143	0.413	0.275
12	I	0.771	1.245	0.871	0.529	0.710	0.748	0.634	0.301	0.243	0.275
13	I	0.827	0.407	1.143	0.664	0.828	0.465	0.460	0.368	0.713	0.275
14	I	0.187	0.811	1.863	1.060	1.229	1.110	0.833	0.579	1.069	0.275
15	I	0.560	0.499	0.535	0.627	0.560	0.518	0.393	0.317	0.307	0.275
4+	I	0.554	0.511	0.577	0.621	0.567	0.521	0.396	0.315	0.309	0.275

Table 17. Results of projections to 1985 for Cod in NAFO Divs. 4RS 3Pn assuming $F_{0.1}$ (0.2) in 1984 and 1985.

POPULATION NUMBERS 7/ 5/84

I	1983	1984	1985
4 I	129675	111000	111000
5 I	127476	104633	89921
6 I	141806	95708	80436
7 I	51903	97070	68793
8 I	32799	32278	65068
9 I	19670	20397	21636
10 I	7556	12233	13673
11 I	3399	4699	8200
12 I	946	2114	3150
13 I	608	588	1417
14 I	100	378	394
15 I	43	62	253
4+I	515980	481159	463940
5+I	386305	370159	352940
6+I	258829	265526	263019
7+I	117023	169818	182584

CATCH BIOMASS 7/ 5/84

I	1983	1984	1985
4 I	1375	858	858
5 I	10513	6347	5455
6 I	30124	15130	12716
7 I	20482	28845	20442
8 I	15593	11555	23293
9 I	11628	9079	9631
10 I	6057	7384	8253
11 I	3594	3742	6530
12 I	1207	2031	3027
13 I	784	572	1377
14 I	159	450	470
15 I	167	69	279
4+I	101683	86061	92330
5+I	100308	85203	91472
6+I	89795	78857	86018
7+I	59671	63726	73302

POPULATION BIOMASS (AVERAGE) 7/ 5/84

I	1983	1984	1985
4 I	94337.91	80906.71	80906.71
5 I	121363.29	100745.08	86579.66
6 I	168268.88	116207.72	97664.40
7 I	74479.63	144222.51	102209.61
8 I	56700.24	57773.37	116464.35
9 I	42282.31	45396.42	48154.19
10 I	22025.27	36920.89	41267.17
11 I	13070.05	18709.07	32649.24
12 I	4388.40	10155.97	15134.43
13 I	2851.68	2857.80	6885.21
14 I	578.24	2250.87	2348.28
15 I	166.81	344.46	1395.87
4+I	600514.71	616490.86	631659.12
5+I	506176.81	535584.15	550752.41
6+I	384813.52	434839.06	464172.74
7+I	216544.63	318631.34	366508.35

FISHING MORTALITY 7/ 5/84

I	1983	1984	1985
4 I	0.015	0.011	0.011
5 I	0.087	0.063	0.063
6 I	0.179	0.130	0.130
7 I	0.275	0.200	0.200
8 I	0.275	0.200	0.200
9 I	0.275	0.200	0.200
10 I	0.275	0.200	0.200
11 I	0.275	0.200	0.200
12 I	0.275	0.200	0.200
13 I	0.275	0.200	0.200
14 I	0.275	0.200	0.200
15 I	0.990	0.200	0.200
4+I	0.137	0.113	0.116

Table 18. Results of projections to 1985 for Cod in NAFO Divs. 4RS 3Pn assuming that the TAC of 100 000 T is taken in 1984 and $F_{0.1}$ (0.2) in 1985.

POPULATION NUMBERS 7/ 5/84

I	1983	1984	1985
4 I	129675	111000	111000
5 I	127476	104633	89750
6 I	141806	95708	79533
7 I	51903	97070	67207
8 I	32799	32278	62778
9 I	19670	20397	20875
10 I	7556	12233	13191
11 I	3399	4699	7911
12 I	946	2114	3039
13 I	608	588	1367
14 I	100	378	380
15 I	43	62	244
4+I	515980	481159	457276
5+I	386305	370159	346276
6+I	258829	265526	256526
7+I	117023	169818	176993

CATCH BIOMASS 7/ 5/84

I	1983	1984	1985
4 I	1375	1010	858
5 I	10513	7444	5444
6 I	30124	17646	12573
7 I	20482	33450	19971
8 I	15593	13399	22473
9 I	11628	10529	9292
10 I	6057	8563	7963
11 I	3594	4339	6300
12 I	1207	2355	2920
13 I	784	663	1329
14 I	159	522	453
15 I	167	80	269
4+I	101683	100000	89845
5+I	100308	98990	88987
6+I	89795	91546	83543
7+I	59671	73900	70970

POPULATION BIOMASS (AVERAGE) 7/ 5/84

I	1983	1984	1985
4 I	94337.91	80832.63	80906.71
5 I	121363.29	100203.45	86415.41
6 I	168268.88	114936.53	96568.33
7 I	74479.63	141838.18	99853.17
8 I	56700.24	56818.24	112365.38
9 I	42282.31	44645.91	46459.41
10 I	22025.27	36310.50	39814.78
11 I	13070.05	18399.77	31500.14
12 I	4388.40	9988.06	14601.77
13 I	2851.68	2810.56	6642.88
14 I	578.24	2213.65	2265.64
15 I	168.81	338.76	1346.74
4+I	600514.71	609336.25	618740.36
5+I	506176.81	528503.62	537833.65
6+I	384813.52	428300.16	451418.24
7+I	216544.63	313363.64	354849.91

FISHING MORTALITY 7/ 5/84

I	1983	1984	1985
4 I	0.015	0.012	0.011
5 I	0.087	0.074	0.063
6 I	0.179	0.154	0.130
7 I	0.275	0.236	0.200
8 I	0.275	0.236	0.200
9 I	0.275	0.236	0.200
10 I	0.275	0.236	0.200
11 I	0.275	0.236	0.200
12 I	0.275	0.236	0.200
13 I	0.275	0.236	0.200
14 I	0.275	0.236	0.200
15 I	0.990	0.236	0.200
4+I	0.137	0.133	0.115

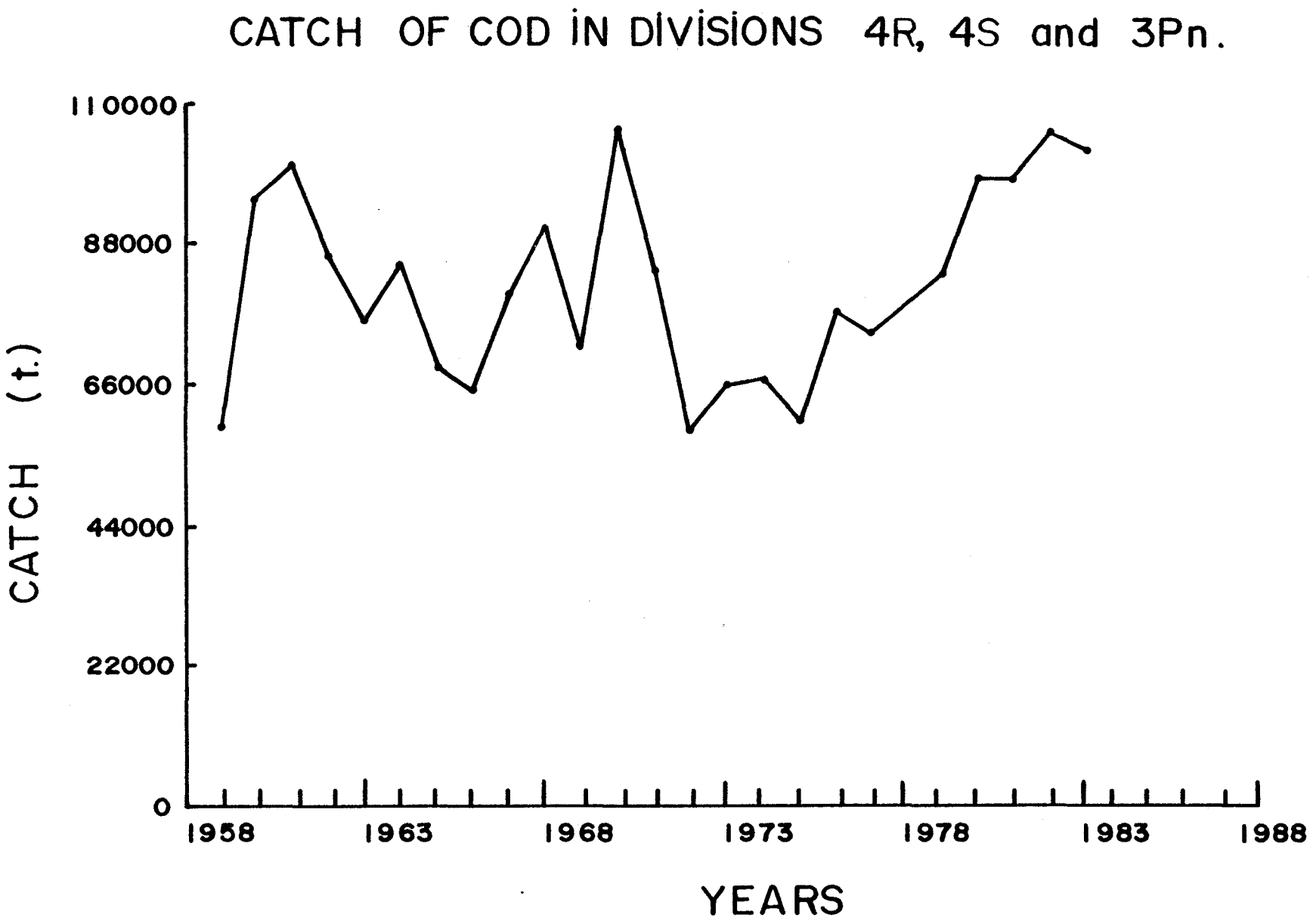


Figure 1. Historical landings (in tonnes) of cod from Divs. 4RS 3Pn between 1959 and 1983.

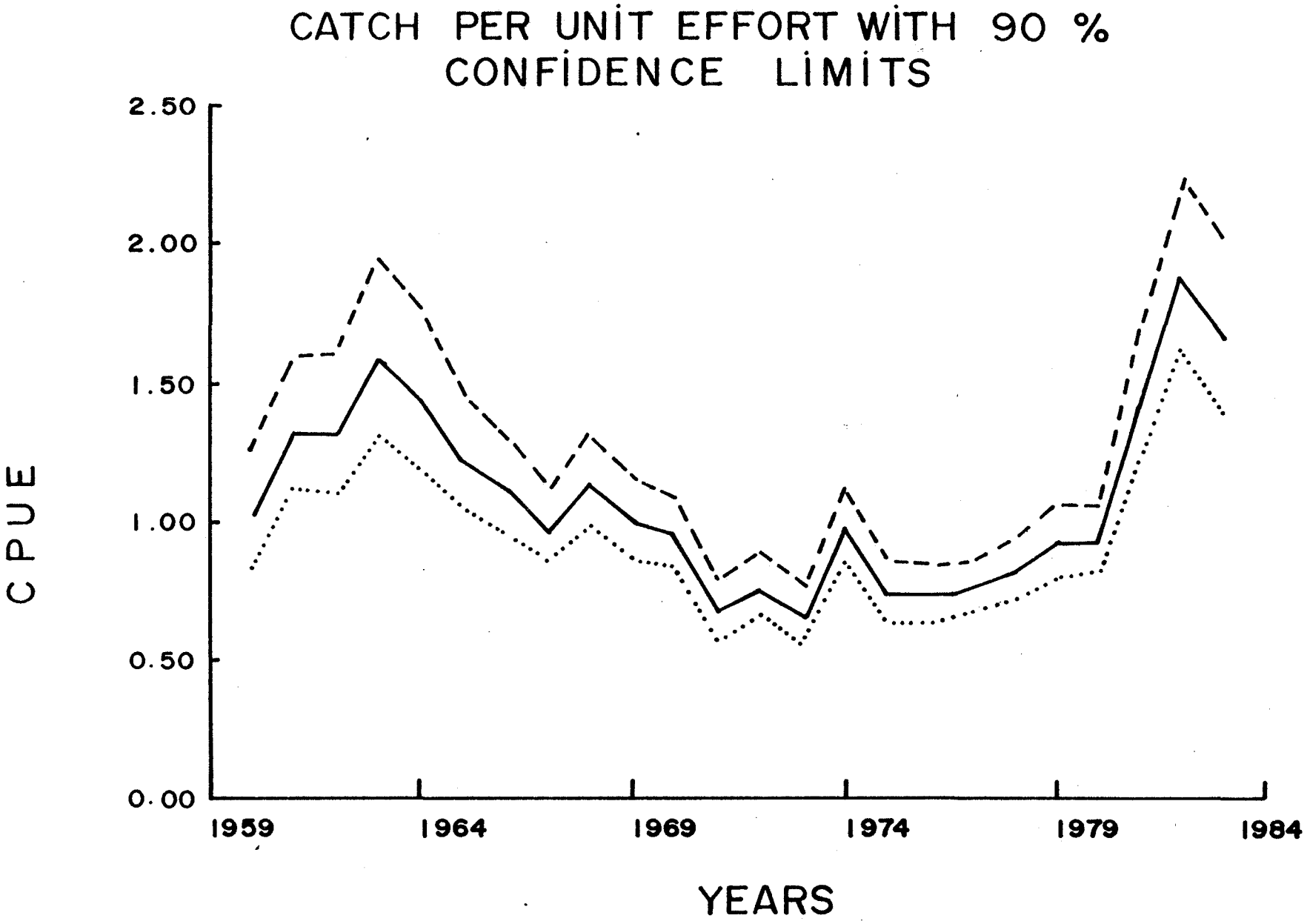


Figure 2. Standardized catch rates (in tonnes/hours) for cod in NAFO divisions 4RS, 3Pn between 1960 and 1983 with the 90% confidence limits.

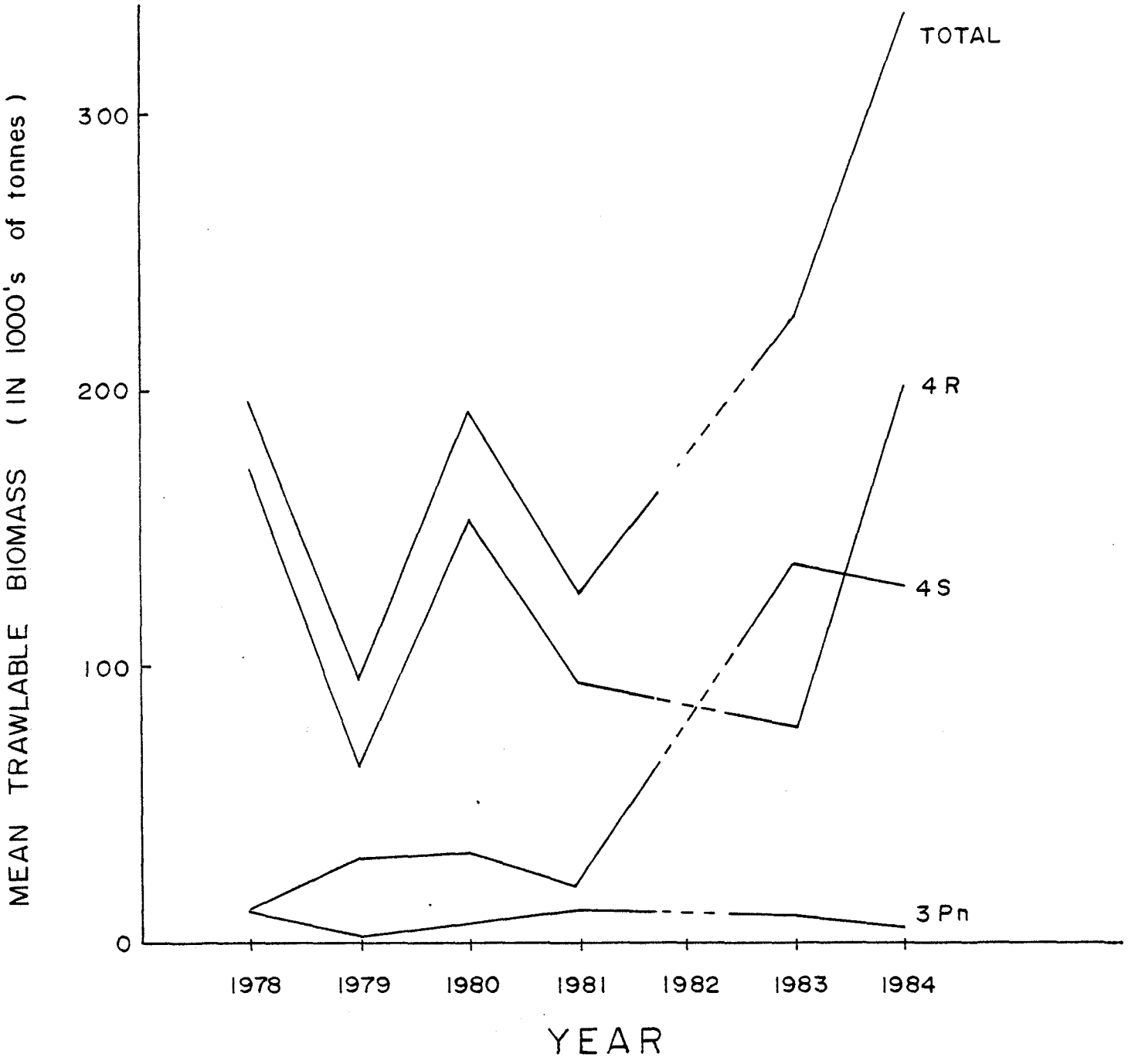
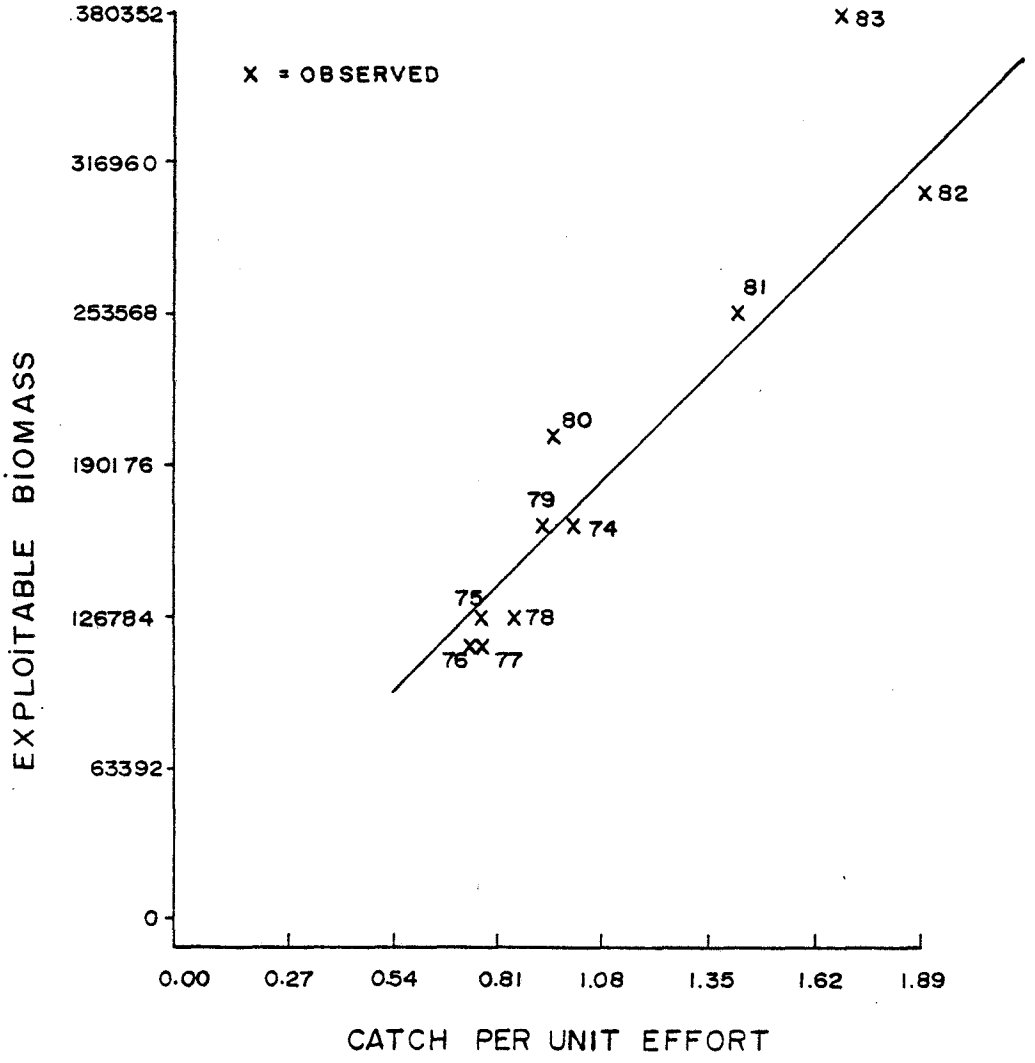


Figure 3. Mean trawlable biomass (per divisions and total) of cod in NAFO divisions 4RS 3Pn as estimated by the random stratified surveys conducted on the Gadus atlantica.

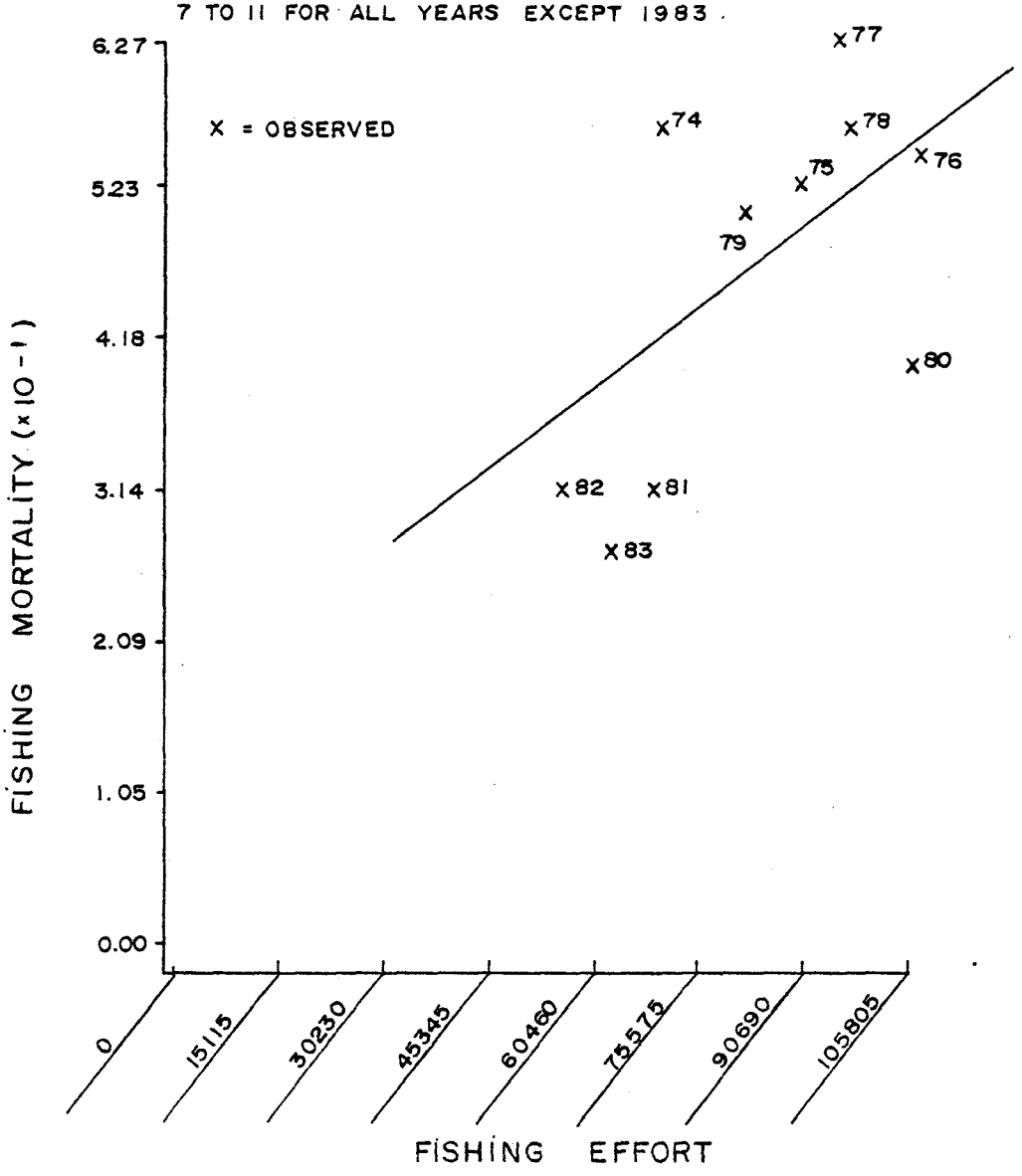
Figure 4: VPA: CODS OF 4RS, 3Pn : REGRESSION ANALYSIS BETWEEN CATCH PER UNIT EFFORT AND EXPLOITABLE BIOMASS AT Ft = 0.275. INCLUDED AGES: 4 TO 15 FOR ALL YEARS EXCEPT 1983.



REGRESSION ANALYSIS

		ALL YEARS			1983 EXCLUDED		
YEARS	INDEPENDENT	OB.	PR.	RESIDUALS	OB	PR.	RESIDUALS
1974	0.959	159495	169862	10368	159495	164968	5474
1975	0.743	131806	125839	-5967	131806	128585	-3220
1976	0.728	113942	122781	8839	113942	126059	12116
1977	0.755	115544	128284	12740	115544	130607	15062
1978	0.817	131459	140921	9461	131459	141050	9591
1979	0.916	160978	161098	120	160978	157725	-3253
1980	0.930	197959	163952	-34007	197959	160084	-37875
1981	1.417	249556	263209	13652	249556	242114	-7443
1982	1.871	309037	355740	46704	309037	318585	9549
1983	1.688	380352	318442	-61910	380352	287761	-92591
CORRELATION :			9.45E-1			9.70E-1	
INTERCEPT :			-2.56E4			3.43E3	
SLOPE :			2.04E5			1.68E5	

Figure 5: VPA: CODS OF 4RS, 3Pn: REGRESSION ANALYSIS BETWEEN FISHING EFFORT AND FISHING MORTALITY AT Ft: 0.275. INCLUDED AGES: 7 TO 11 FOR ALL YEARS EXCEPT 1983.



REGRESSION ANALYSIS

YEARS	INDEPENDENT	ALL YEARS OB.	ALL YEARS PR.	ALL YEARS RESIDUALS	1983 EXCLUDED OB.	1983 EXCLUDED PR.	1983 EXCLUDED RESIDUALS
1974	69247.000	0.560	0.399	-0.161	0.560	0.423	-0.136
1975	81082.000	0.499	0.450	-0.048	0.499	0.464	-0.035
1976	105807.000	0.535	0.557	0.022	0.535	0.549	0.015
1977	97464.000	0.627	0.521	-0.106	0.627	0.521	-0.107
1978	96039.000	0.560	0.515	-0.045	0.560	0.516	-0.044
1979	90363.000	0.518	0.490	-0.028	0.518	0.496	-0.022
1980	104980.000	0.393	0.554	0.160	0.393	0.547	0.153
1981	69082.000	0.317	0.398	0.081	0.317	0.423	0.105
1982	56066.000	0.307	0.342	0.035	0.307	0.378	0.071
1983	61522.000	0.275	0.365	0.090	0.275	0.396	0.121
CORRELATION:			6.33E-1			5.37E-1	
INTERCEPT :			9.90E-2			1.84E-1	
SLOPE :			4.33E-6			3.46E-6	