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STATUS OF THE ATLANTIC COD STOCK ON GEORGES BANK IN UNIT AREAS 5Zj and 5Zm, 1978-88

by

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Abstract

A newly defined management unit for the Atlantic cod stock in unit areas 5Zj and 5Zm was the basis for a review of stock status for 1978-88. Total landings peaked at 26000 t in 1982, have averaged about 16000 t and were 20368 t in 1988. Canada accounts for about 65% of the total catch. In 1988, most of the catch was made up of the 1985 and 1983 year-classes. No survey indices specific to 5Zj and 5Zm are available for this stock. Catch per tow in both the USA spring and fall survey of Division 5Ze increased in 1988 but remain at relatively low values. The Canadian spring survey catch per tow has been increasing since 1987. Standardized C/E for Canadian and USA otter trawlers have shown a general decline since 1978. Uncertainties regarding input data preclude a detailed analysis of stock status at the present time. However, results of SPA using an average F in 1988 indicate fishing mortalities 2-3 times $F_{0.1}$ are associated with recent catches of 15000-20000 t and the fishery is largely dependent on recruiting year-classes. Reduction of total catch by a factor of 2 in 1990 is required if $F_{0.1}$ management objectives are to be approximated.

Résumé

La création d'une nouvelle unité de gestion du stock de morue de l'Atlantique dans les secteurs 5Zj et 5Zm a donné lieu à une étude de l'état des stocks de 1978 à 1988. Les débarquements totaux ont culminé à 26 000 t en 1982, pour s'établir en moyenne à 16 000 t; en 1988, ils atteignaient 20 368 t. La part canadienne des prises totales est d'environ 65 %. En 1988, la majeure partie des prises se composait de poissons appartenant aux classes de 1985 et 1983. Aucune donnée de recherche propre aux secteurs 5Zj et 5Zm n'existe pour ce stock. Il ressort des relevés de recherche effectuées par les Etats-Unis dans la sous-division 5Ze au printemps et à l'automne que les prises par trait ont augmenté en 1988, tout en conservant une valeur relativement faible. Les prises par trait effectuées lors des relevés de recherche canadiennes du printemps ont augmenté depuis 1987. Les PUE normalisées des bateaux canadiens et américains pêchant au chalut à panneaux dénotent une régression générale depuis 1978. L'incertitude au sujet des intrants empêche de réaliser une analyse détaillé de l'état des stocks pour le moment. Toutefois, les résultats des ASP fondées sur un F moyen en 1988 révèlent que les prises récentes de 15 000 à 20 000 t correspondent à des taux de mortalité équivalent à deux or trois fois $F_{0.1}$, et que la pêche dépend largement des classe d'âge recrutées. Il s'avère nécessaire de réduire les prises totales par un facteur de 2 en 1990 si l'on veut approacher des objectifs de gestion correspondant à $F_{0.1}$.

Introduction

The cod fishery in Division 5Z and Subarea 6 has been managed independently by Canada and the USA since 1978. Canada recommended TAC's for 1978-84, while the USA has followed their Groundfish Management Plan since 1981. Canada set Canadian quotas for 1985-88.

Hunt and Waiwood (1984, 1985) and Hunt and Gavaris (1986), in reviews of stock status, suggested fully recruited fishing mortalities well above the F_{max} of 0.25 since 1983. In the most recent assessment of this stock, Hunt (1988) reported a fully recruited fishing mortality of 0.8 in 1987 for the total Division 5Z plus Subarea 6 area.

The present report incorporates 1988 commercial catch data and research survey results to estimate stock status for the 1978-88 time period in the two unit areas 5Zj and 5Zm. Definition of this management unit is based on analysis of tagging results as well as commercial and survey catch distribution and more recent tagging studies (see Appendix I).

Cod are taken by both Canada and the USA in unit areas 5Zj and 5Zm and all data relating to USA catches, C/E and research vessel surveys were provided by the National Marine Fisheries Service (NMFS) through Dr. Fred Serchuk at the Woods Hole, Mass., Laboratory.

Trends in Reported Landings

Catches from 5Zj and 5Zm are thought to be under- or mis-reported prior to 1978 and estimates of population status prior to this time are suspect (Hunt, 1987). Catch statistics since 1977, when foreign fleets were excluded from the 200 mile economic zones of Canada and the USA, are thought to be more reliable. There have been no reported landings by foreign fleets since 1978.

Annual Landings

The USA has been the main harvester of cod in Division 5Z and Subarea 6. Total landings declined to about 20000 t in 1976 but then increased to the maximum recorded value of 57195 t in 1982. Catch in 1988 is estimated to be about 44800 t (USA 32100 t and Canada 12700 t).

Reported landings by Canada are confined to 5Zj and 5Zm and, since 1985, to the Canadian zone of these two unit areas. USA catches are taken throughout the 5Ze area with peak catches in 5Zeg and are summarized by unit area in Table 1.

Fishery by Country and Gear

The USA cod fishery in 5Zj and 5Zm is almost exclusively by otter trawlers. Catches peaked at about 10500 t in 1984, fell to about 5000 t in 1987 and increased to about 7600 t in 1988.

Canadian catches of cod are taken on the "Northeast Peak" of Georges Bank primarily between April and November. Landings have been

dominated by otter trawlers, except for 1984 (Table 2, Fig. 1). In 1987, both otter trawl and longline catches increased (22% and 60%, respectively) over 1986 and the catch by gillnet increased 300% to 1155 t, the highest in the time series. In 1988, otter trawlers, longliners and gillnetters accounted for 60%, 35% and 5%, respectively, of the 12700 t catch.

Catches by Canada and the USA in 5Zj and 5Zm for 1978-88 are summarized in Table 3 and in Figure 2. Catches peaked at 26000 t in 1982, averaged to about 16000 t between 1983-87 and increased to 20000 t in 1988. Since 1985, Canada has taken about 65% of the total catch.

Age Composition of the Commercial Catch

Sampling Intensity

Sampling coverage of the Canadian fishery prior to 1985 averaged about one sample per 1000 t landed. In 1985, 18 samples were collected, 19 in 1986 with a substantial increase to 33 samples in 1987 and 40 in 1988. Prior to 1978, sampling levels for Canadian catches were very low and it is unlikely that reliable estimates of removals at age could be obtained.

Age Composition

Canadian samples were used to obtain statistics by age according to the method described by Gavaris and Gavaris (1983). The bias introduced by applying otter trawl length frequencies to partition longline catches may be significant in years lacking samples for this gear. A summary of catches and samples used to estimate removals at age for 1988 is given Table 4. Percent age composition of Canadian catches are shown in Table 5. The 1985 year-class accounted for 66% of the catch in numbers and 45% in weight.

For the length weight relationship, values for a and b were derived from Canadian commercial sampling data. With round weight in kilograms and length in centimeters and these values were a=0.0000163 and b=2.9048 and they were used for both Canadian and USA sampling data.

Catch at age in the USA fishery for 1978-87 was estimated by prorating the reported total removals by the ratio of 5Zj and 5Zm to total catches for each year. This assumes a similar distribution for age groups throughout the total 5Z area, although there is some evidence from surveys to suggest that differences between the eastern and western extremes of 5Z exist. The extent of spatial differences in proportional catch at age will be assessed when USA sampling data specific to 5Zj and 5Zm are made available.

USA sampling for 1988 was not complete and consisted of one age key for the first quarter and length frequency samples for the first to third quarters. Catch at age in 1988 was initially estimated by quarter using the USA age key to partition length frequencies in quarters 1 and 2 and a Canadian age key for quarter 3 length frequencies. Quarter 3 samples were assumed to reflect catches in the second half of the year. However, examination of the key indicated only 2 age two fish from a total of over 400 age determinations, which resulted in a very low

estimate for catch at age two. Lengths corresponding to age two fish were evident in the length frequency data and it was therefore decided to partition the USA length frequency samples using Canadian age length keys (Figure 3).

In 1987 and 1988, percent catch at age by Canada and the USA were similar, although slightly greater numbers of the 1983 year-class at age 4 were reported in USA landings. Catch at age by country is given in Table 6.

Mean length and weight at age for Canadian samples are given in Tables 7 and 8, with the plus age group set to 115 cm and 15 kg, the approximate mean for ages 10-15.

Stock Abundance Trends

Research Surveys

Random, depth-stratified bottom trawl surveys have been conducted by the USA in the autumn since 1963 and a spring survey was added in 1968. A summer survey was conducted from 1977 to 1981. Surveys in Subdivision 5Ze were completed by Canada in March 1986-89. Mean catch per tow in numbers by age group for each of the USA surveys is given in Table 9. No adjustment for different gears or vessels used during the time series has been made. The spring survey used the larger "Yankee 41" trawl from 1973-81 and considerable differences in catch per tow could be anticipated. Total net opening of the "41" trawl is about 1.7 times the opening of the "Yankee 36".

New trawl doors have been used for both spring and autumn surveys since 1985. Preliminary analysis of a study to develop conversion factors indicates the new trawl doors are more effective and would increase the catches of cod and haddock (pers. comm., Dr. F. Serchuk, NMFS). The value of the conversion factor has not been resolved and catches since 1985 should be considered an over-estimate relative to pre-1985 levels.

The spring survey has shown a decline in 0+ numbers between 1981-84, when the same sampling gear was used, and was at the lowest observed level in 1984. An increase in 1985 was followed by a decline in 1986 and the 1987 survey was the second lowest level since 1971. The 1988 survey increased, primarily due to the strong evidence of the 1985 year-class at age 3. The autumn survey has been relatively stable since 1982 with below average catches and shows a slight increase in the 1986 followed by a decline in 1987. The total catch per tow in 1988 increased and was similar to the 1986 value.

Survey catch rates are not available by unit area and it was necessary to assume constant relative density across the survey area in order to use the total index as an index for 5Zj and 5Zm. USA strata 16-21 approximate the 5Zj and 5Zm area but the proportion of the catch by stratum given in Table 10a,b indicates variable contribution between 1970-86. Strata 16-21 account for about 50% of the total numbers but varied between 17 and 78% for 1978-86.

Canada has conducted a stratified random bottom trawl survey using a

Western IIa trawl in Subdivision 5Ze during March 1986-89. Results of this survey are given in Table 11 but catch levels are not directly comparable with USA catches due to the difference in vessel and gear type. The Canadian survey also uses different strata than the USA survey and incorporates the International boundary in strata margins. For the four survey years, abundance has been variable with similar numbers in 1986 and 1988 but lower in 1987. The stratified mean for 1989 was the highest in the series. The 1984 year-class at age 2 in 1986 seems strong but is below average in 1987 and 1988, suggesting that the 1986 catch is an over-estimate. The 1985 and 1987 year-classes account for most of the catch in numbers in 1989. There is not an appropriate subset of the Canadian strata which conforms to 5Zj and 5Zm and it will necessary to redefine boundaries for subsequent surveys to meet this requirement.

The stratified mean catch per tow for 5Ze in the USA fall survey and Canadian spring survey are summarized in Figure 4.

Commercial Catch Rates

Catch and effort statistics by month and gear, for the Canadian fishery, were derived from Table 5 of the NAFO/ICNAF Statistical Bulletins for 1967-83. Data for 1984-88 were obtained from the Canadian Department of Fisheries and Oceans. A multiplicative model (Gavaris, 1980) was used. All observations where either the catch was less than 10 t or the effort was less than 10 hours were excluded from the analysis.

Examination of the residuals from the preliminary unweighted analysis resulted in the exclusion of three observations: OTB2-4, April 1967; OTB2-2 December 1968; OTB2-2, October 1982. There were no annual trends in either month or gear residuals but observations with lower catch and effort were more variable. Therefore a weighted analysis was applied. An iterative procedure described by Judge et al (1980) was used to estimate the weights based on the partitioning of residuals along a logarithmic (catch x effort) scale. The analysis of variance from the weighted regression indicates that months do not account for much of the systematic variation. The coefficients for gears follow an intuitive pattern with larger vessels associated with greater fishing power.

The results of the analysis are shown in Table 12 in the re-transformed linear scale. Trends in the linear scale (Figure 5) indicate fairly low C/E in the mid-1970's with an abrupt increase in 1977 probably due to the recruitment of the 1975 year-class. This is followed by a general decline, although catch rates increased somewhat in 1981-82 and 1985, probably due to recruitment of the 1980 and 1983 year-classes, respectively. Both the 1986 and 1987 C/E decreased from 1985. The 1988 C/E was slightly higher compared to 1987. Total effort also peaked in 1983, declined until 1986 but increased in 1987 and remained high in 1988.

A 1978-87 subset of the Canadian total series was also examined. The shorter time series was assumed to minimize the effect of learning and potential improved efficiency which may have taken place in the early to mid 70's when fleet expansion occurred. Results of analysis of this data set were similar to those obtained with the 1967-88 series (Table 12).

Catch and directed effort (>50% cod) for USA otter trawlers for 1979-87 were available by unit area and a standardized catch rate was estimated using the multiplicative model. Results are given in Table 12 and indicate substantial reduction in C/E between 1980 and 1987.

Comparison of the three catch rates examined is given in Figure 5. The 1967-88 and 1978-87 Canadian series show similar trends with a general decline since 1978. The USA C/E is less than 20% of the Canadian C/E but shows a similar decline and was at its lowest value in 1988. The abrupt increase in Canadian C/E observed in 1977 is not supported by an equivalent increase in stock biomass and may reflect improved efficiency. Therefore, it is considered more appropriate to use only the post-1978 commercial indices of abundance.

Sequential Population Analysis (SPA)

Catch at age may be inaccurate due to spatial differences in the proportion at age in the USA fishery. Research survey indices are not specific to the management unit. Examination of Canadian C/E and fishable biomass estimated from the converged part of the population matrix (1978-83) indicates poor correlation. These uncertainties in data preclude an analytical assessment of stock status in 5Zj and 5Zm at the present time. However, to obtain an overview of stock status, the ADAPT model (Gavaris, 1988) was used with the following formulation:

Parameters

- Year-class estimates N_i, 1988 $i = 1$ to 5
- Calibration constants for RV numbers K_i $i = 1$ to 5

Structure

- natural mortality was set to 0.2
- error in catch at age assumed negligible
- F for agegroups 6-9 in 1988 and at age 9 for other years was calculated as the weighted F for ages 3 -5
- intercepts not included

Input

- $C_{i,t}$ $i = 1$ to 9, $t = 1978$ to 1988
- $RV_{i,t}$ $i = 1$ to 9, $t = 1978$ to 1988

Objective function

- minimize $\sum(\text{obs } (\ln RV_{i,t}) - \sum(\text{pred } (\ln RV_{i,t}))^2$
- beginning of year estimates of population size were fished down to coincide with the median month of the survey (October)

Summary

- number of observations = 55
- number of parameters = 10

The model converged and gave significant estimates for all five slopes but gave significant population estimates only for ages 3-5. Fully recruited fishing mortality (3+) was estimated at 0.667 in 1988. Between 1978 and 1987, fully recruited fishing mortality fluctuated around a mean of about 0.5.

Mean SPA Run

To provide a rough approximation of stock status, an SPA was run with an F_t of 0.5, the approximate mean for 1978-87, as indicated from the above ADAPT run.

Fishing mortality (3+) averaged to 0.35 between 1978-81 but increased to an average of 0.48 in the 1983-87 time period. Fishing mortalities reached a high of 0.55 in 1985 and have exceeded F_{max} over the entire time series as shown in Figure 6.

Estimated 1+ population numbers ranged from 30-38 million for 1978-82 but decreased to 24 million in 1983 and have remained low since with some variability associated with recruitment. Numbers at 3+ are strongly influenced by recruitment. Similar results are apparent in the estimate of 3+ population biomass, which has varied between 23000 and 42000 t. Estimated recruitment at age 1 and 3+ numbers are shown in Figure 7. Estimated 3+ biomass is given in Figure 8.

Yield per Recruit Analysis

Mean weight at age for ages 1-15 were derived from Canadian commercial catch samples. Very few fish older than 15 years are taken in the fishery and the level of sampling for these agegroups is inadequate to provide reliable estimates of weight at age.

Partial recruitment was determined from the fishing mortality matrix for 1978-86 for ages 1 and 2 with full recruitment assumed for ages 3 and older. Increased effort on strong recruiting yearclasses is evident in this fishery and partial recruitment at age two varies between 13 and 65 percent (Figure 8). The overall mean partial recruitment at age two for 1978-86 was about 36%.

Results of yield per recruit analysis, using the Thompson and Bell model, indicate $F_{0.1}$ is 0.166 and F_{max} 0.283 with corresponding yields of 1.656 and 1.766 kg, respectively. With geometric mean recruitment at age 1 of about 9 million, the long term yield from this stock is about 14900 t. For most cod stocks in the Northwest Atlantic, $F_{0.1}$ exploitation occurs at a fully recruited fishing mortality of about 0.20.

Prognosis

Assumptions used to generate input values cause the estimated stock size at the beginning of 1989 to have a degree of uncertainty

which limits the validity of catch projections for 1990. Projected catches for 1989 are 8000 t for Canada (Canadian allocation) and 7000 t for the USA (assumed the same as in 1988) which would result in a total catch of 15000 t, well above the $F_{0.1}$ exploitation yield. Fishing mortalities and associated catches since 1978 have been 2-3 times the $F_{0.1}$ value which imply it would be necessary to reduce total catches (Canadian and USA) by 2-3 times to achieve $F_{0.1}$ exploitation.

Management Considerations

Implementation of a new management unit (5Zj and 5Zm) is based on an analysis of catch, effort, tagging and biological parameters (Appendix 1). Results of this study indicate that the 5Zj and 5Zm area is sufficiently isolated from adjacent areas to justify definition of the management unit.

Reducing catches by Canada to a level consistent with an F0.1 management strategy would not result in substantial increases in yield to the Canadian fleet and any decrease in effort by Canada would result in increased catch rates for the USA. Reduced effort by Canada could help rebuild the stock, but this is likely to be negated by increased effort by the USA in response to increased catch rates. The 5Zj and 5Zm management unit includes catches by both Canada and the USA and it will be necessary to develop consistent management.

Acknowledgments

The co-operation and assistance provided by the National Marine Fisheries Service through Drs. Fred Serchuk and Ralph Mayo in compiling USA sampling, catch and effort data for the 5Zj and 5Zm area is very much appreciated. These data will continue to be an essential element for provision of advice on this stock.

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Table 1. Summary of cod catches by USA in unit areas, 1964-87.

Year	5Zeg	5Zeh	5Zej	5Zem	5Zen	5Zeo	5ZwSA6	Total
64	4245.2	1720.2	3106.2	1708.2	283.5	961.1	238.1	12262.5
65	3233.9	2558.8	1753.2	2518.7	377.5	687.1	217.8	11347.0
66	4036.4	1950.3	1619.9	2240.2	600.0	935.2	359.1	11741.1
67	5293.4	2244.4	1290.2	1824.4	418.0	767.7	725.7	12563.9
68	5866.1	2900.0	1548.6	1695.6	487.0	1047.0	1053.1	14597.3
69	7413.3	2566.2	1104.2	2571.8	417.6	879.1	1285.9	16238.0
70	5666.3	2577.3	1353.7	1856.7	694.5	1201.7	1148.2	14498.5
71	6409.6	2435.0	1074.3	3314.5	743.8	1024.6	822.9	15824.6
72	5627.7	2372.4	1159.2	1549.0	845.7	922.7	778.3	13255.1
73	7659.9	2189.0	1512.9	1551.0	651.8	1282.0	1163.6	16010.2
74	7699.4	2534.9	1772.7	2019.5	848.0	1774.0	1280.6	17929.1
75	8147.1	1635.4	1631.2	1476.8	863.4	837.9	666.3	15258.0
76	8438.0	1980.9	964.3	1073.1	503.2	978.9	321.5	14259.9
77	9829.8	3258.3	2176.6	2078.9	789.1	1442.7	787.4	20362.9
78	11953.6	3230.3	2737.4	2764.8	1310.6	1790.1	1669.7	25456.5
79	16915.8	5267.0	3683.3	2724.3	833.2	1483.9	844.1	31751.6
80	21078.6	6690.2	3691.7	2726.8	2318.4	1858.6	664.2	39028.4
81	15616.1	5089.0	4884.2	3151.2	2059.0	1087.2	949.5	32836.2
82	20620.2	5203.9	4886.1	3678.8	1183.0	1942.4	928.5	38443.0
83	16357.6	6446.6	5295.0	3277.3	780.0	1989.4	1788.7	35934.6
84	11605.0	4214.7	5479.7	5070.7	1874.8	1805.6	1986.3	32036.8
85	11135.5	3755.2	2208.9	4432.3	1204.1	2066.9	1292.0	26095.0
86	6556.0	1966.8	1926.0	3770.4	617.4	1510.8	927.5	17275.0
87	7390.2	3625.7	2074.3	2717.4	593.6	760.6	1591.0	18752.9
Mean %								
1964-84	46.1	15.6	11.9	11.5	4.3	6.0	4.5	
1985-87	40.4	15.0	10.9	17.6	3.9	7.0	6.1	

Table 2. Nominal landings of cod by gear and month for Canada(M) in 5Zj and 5Zm. (Ot - otter trawl; LL - longline; Misc - miscellaneous, mostly gillnet)

Year	Gear	Month												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
78	Ot	167	763	241	26	305	1943	1139	22	220	1733	1625	-	8184
	LL	-	-	-	-	11	193	295	128	74	19	-	-	720
	Misc	-	-	-	1	-	-	1	-	-	-	-	-	2
	Total	167	763	241	27	316	2136	1435	150	294	1752	1625	-	8906
79	Ot	72	301	179	78	74	1635	667	675	661	294	28	7	4671
	LL	-	-	-	5	20	528	333	305	136	11	-	-	1338
	Misc	-	-	1	-	1	-	-	-	-	-	-	-	2
	Total	72	301	180	83	95	2163	1000	980	797	305	28	7	6011
80	Ot	23	86	4	53	110	1374	1594	786	637	617	69	100	5453
	LL	-	-	-	-	208	950	596	496	337	47	-	-	2634
	Misc	-	-	1	2	1	2	1	-	-	-	-	-	7
	Total	23	86	5	55	319	2326	2191	1282	974	664	69	100	8094
81	Ot	2	204	55	8	38	540	1005	743	1024	36	230	98	3983
	LL	-	-	1	2	537	1476	1043	837	286	281	56	5	4524
	Misc	-	-	-	1	-	-	-	-	-	-	-	-	1
	Total	2	204	56	11	575	2016	2048	1580	1310	317	286	103	8508
82	Ot	89	74	-	-	12	882	4283	2112	1509	2361	932	119	12372
	LL	-	11	26	195	773	1036	1386	1083	634	307	34	4	5489
	Misc	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	89	85	26	195	785	1918	5669	3195	2143	2668	966	123	17862
83	Ot	179	80	9	6	35	2215	1094	2115	957	173	75	11	6949
	LL	-	-	171	147	439	1441	699	576	1304	309	89	-	5175
	Misc	-	-	-	-	-	6	34	3	5	1	-	-	49
	Total	179	80	180	153	474	3662	1827	2694	2266	483	164	11	12173
84	Ot	5	3	13	1	39	272	93	239	61	19	-	-	745
	LL	-	-	167	152	111	1192	1210	1183	605	286	49	-	4955
	Misc	-	-	-	-	-	52	9	-	-	-	-	-	61
	Total	5	3	180	153	150	1516	1312	1422	666	305	49	-	5761
85	Ot	-	2	-	-	165	1172	2561	2431	692	435	4	80	7546
	LL	-	29	54	181	151	414	230	542	647	501	29	29	2807
	Misc	-	1	2	14	15	24	9	19	4	2	1	1	92
	Total	-	32	56	195	331	1606	2800	2992	1343	938	34	110	10441
86	Ot	15	9	-	15	6	2364	3137	477	49	11	4	22	6109
	LL	-	58	81	12	24	146	120	538	606	409	12	-	2006
	Misc	1	2	9	15	10	47	89	76	42	1	-	-	292
	Total	16	69	90	42	40	2557	3346	1091	697	421	16	22	8407
87	Ot	18	1	3	-	-	2485	3811	889	145	2	78	44	7476
	LL	-	6	112	68	8	292	591	1032	747	310	13	33	3212
	Misc	5	11	15	17	9	142	466	391	89	2	6	2	1155
	Total	23	18	130	85	17	2919	4868	2311	981	314	97	78	11843
88	Ot	23	520	57	-	13	3153	3138	416	18	99	29	9	7575
	LL	54	86	68	205	27	1247	1686	392	386	114	10	1	4276
	Misc	2	9	12	10	16	221	319	238	102	21	20	2	972
	Total	79	615	137	215	56	4621	5143	1046	506	234	59	12	12723

Table 3. Summary of total catches by Canada and the USA in unit areas 5Zj and 5Zm for 1978-88.

Year	Canada	USA	Total
1978	8906	5502	14408
1979	6011	6408	12419
1980	8094	6418	14512
1981	8508	8035	16543
1982	17862	8565	26427
1983	12173	8572	20745
1984	5761	10530	16291
1985	10441	6641	17082
1986	8407	5696	14103
1987	11843	4792	16635
1988	12723	7645	20368

Table 4. Summary of 1988 catch and samples used to estimate catch at age for Canadian landings.

Gear	Month	Weight (t)		Lengths	Ages	Total
OTB	Jan	23				
	Feb	520				
	Mar	57				
	Apr	-	3766	2626	401	
	May	13				
	Jun	3153				
	Jul	3239				
	Aug	416				
	Sep	17				
	Oct	99	3809	2912	448	7575
	Nov	29				
	Dec	9				
LL	Jan	54				
	Feb	86				
	Mar	68				
	Apr	205	1687	2427	548	
	May	27				
	Jun	1247				
	Jul	1685				
	Aug	392				
	Sep	386	2590	2156	334	4277
	Oct	114				
	Nov	10				
	Dec	3				
GN	Jan	-				
	Feb	-				
	Mar	-				
	Apr	-				
	May	-				
	Jun	180	615	405	196	615
	Jul	224				
	Aug	141				
	Sep	49				
	Oct	21				
	Nov	-				
	Dec	-				
Total	Misc	256				12723

Table 5. Age composition (percent by number) derived from biological samples of Atlantic cod from 5Zj and 5Zm taken by Canadian vessels, 1978-88.

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	0.06	0.00	0.03	0.09	0.12	0.45	0.00	0.09	0.83	0.38	0.43
2	1.99	24.64	27.12	9.31	36.71	10.53	1.95	51.57	9.96	62.25	6.67
3	66.40	23.85	40.19	34.14	25.00	39.87	9.10	21.48	54.59	14.92	65.84
4	20.60	35.25	7.74	25.35	16.24	25.67	29.46	8.97	16.01	15.59	8.64
5	6.14	12.29	16.45	6.25	12.15	8.54	30.48	11.93	6.35	1.88	10.61
6	2.24	2.41	5.31	17.19	2.69	6.07	14.03	3.44	9.53	1.70	1.73
7	1.68	0.83	1.31	3.77	4.19	2.47	7.71	1.08	1.30	2.44	1.54
8	0.01	0.02	0.02	0.10	0.02	0.11	0.19	0.02	0.87	0.45	2.89
9	0.30	0.09	0.73	0.90	0.43	1.83	2.13	0.24	0.39	0.29	0.86
10+	0.18	0.09	0.54	0.67	0.80	0.91	3.06	0.24	0.17	0.11	0.76
#samples	29	13	10	17	17	15	7	18	19	33	40
#aged	1364	591	536	491	956	601	412	1064	888	1236	1927

Table 6. Estimated removals at age for the Canadian and USA cod fishery in unit areas 5Zj and 5Zm, 1978-88.

		Agegroup 1	2	3	4	5	6	7	8	9	10+	Total
78	Cdn	2	65	2162	671	200	73	55	12	10	6	3256
	USA	0	69	1186	339	129	11	60	7	6	2	1808
	TOT	2	134	3348	1010	329	84	115	19	16	8	5064
79		0	499	483	714	249	49	17	10	2	2	2025
		7	318	112	806	179	79	12	48	0	9	1569
		7	817	595	1520	428	128	29	58	2	11	3594
80		1	704	1043	201	427	138	34	14	19	14	2595
		14	481	754	46	303	152	66	12	25	0	1853
		15	1185	1797	247	730	290	100	26	44	14	4448
81		2	195	715	531	131	360	79	48	19	14	2094
		6	726	858	465	24	244	78	17	26	11	2455
		8	921	1573	996	155	604	157	65	45	25	4549
82		7	2047	1394	906	678	150	234	91	24	45	5576
		71	1710	537	366	274	25	98	25	11	12	3131
		78	3757	1931	1272	952	175	332	116	35	57	8707
83		15	345	1306	841	280	199	81	118	60	30	3275
		19	826	1296	290	199	168	20	51	21	14	2904
		34	1171	2602	1131	479	367	101	169	81	44	6179
84		0	21	98	317	328	151	83	22	23	33	1076
		26	411	1059	949	160	126	124	8	49	26	2939
		26	432	1157	1266	488	277	207	30	72	59	4015
85		4	2144	893	373	496	143	45	39	10	10	4157
		32	1060	381	244	344	68	43	41	3	21	2236
		36	3204	1274	617	840	211	88	80	13	31	6393
86		19	232	1270	372	148	222	30	20	9	4	2326
		45	355	1071	141	110	134	19	17	12	8	1913
		64	587	2341	513	258	356	49	37	21	12	4239
87		17	2784	667	697	84	76	109	20	13	5	4472
		3	1228	202	347	47	44	39	10	6	5	1930
		20	4012	869	1044	131	120	148	30	19	10	6402
88		16	247	2438	320	393	64	57	107	32	28	3703
		5	174	1009	170	321	61	26	31	11	2	1810
		21	421	3447	490	714	125	83	138	43	30	5513

Table 7. Mean length-at-age of cod derived from Canadian samples, 1978-88.

Year	Age group 1	2	3	4	5	6	7	8	9	10+
1978	36.4	44.3	53.9	57.9	63.6	74.6	76.0	89.9	86.0	115.0
1979	50.7	53.3	69.1	75.3	80.4	95.9	104.4	99.6	115.0	115.0
1980	36.7	49.3	60.1	66.7	78.0	85.7	87.6	105.6	105.2	115.0
1981	42.2	49.2	58.8	67.8	77.4	85.7	94.5	96.0	97.4	115.0
1982	36.8	49.8	57.1	69.8	78.6	84.9	95.0	95.8	107.2	115.0
1983	42.6	50.4	58.4	67.1	77.8	84.8	93.0	99.3	104.4	115.0
1984	-	50.2	60.4	70.2	76.9	83.5	92.2	99.7	101.4	115.0
1985	38.7	49.3	55.3	67.9	74.8	83.2	90.1	95.6	98.8	115.0
1986	39.6	51.7	63.5	71.0	79.7	86.9	92.8	96.2	94.5	115.0
1987	38.5	51.9	60.3	73.5	82.5	88.1	96.2	100.3	106.0	115.0
1988	40.9	48.0	60.3	70.1	79.9	84.5	95.3	100.1	102.3	115.0

Table 8. Mean weight-at-age of cod from Canadian samples, 1978-88.

Year	Agegroup 1	2	3	4	5	6	7	8	9	10+
1978	0.656	1.206	2.121	2.644	3.540	5.682	6.140	9.268	8.399	15.0
1979	-	1.483	1.723	3.691	4.730	5.986	9.586	12.058	10.412	15.0
1980	0.572	1.348	2.427	3.241	5.116	6.707	7.148	12.324	12.169	15.0
1981	0.864	1.368	2.312	3.467	5.113	6.816	9.108	9.575	10.485	15.0
1982	0.592	1.410	2.128	3.814	5.335	6.656	9.158	9.574	12.941	15.0
1983	0.885	1.466	2.265	3.371	5.210	6.641	8.593	10.428	11.999	15.0
1984	-	1.438	2.477	3.841	4.977	6.310	8.541	10.486	11.034	15.0
1985	0.680	1.391	1.950	3.571	4.742	6.399	8.074	9.664	10.584	15.0
1986	0.723	1.573	2.897	3.944	5.623	7.208	8.618	9.512	9.996	15.0
1987	0.660	1.600	2.506	4.447	6.148	7.484	9.538	10.759	12.565	15.0
1988	0.790	1.270	2.489	3.862	5.662	6.641	9.309	10.765	11.636	15.0

Table 9. Stratified mean catch per tow at age (numbers) of Atlantic cod in offshore spring and autumn bottom trawl surveys on Georges Bank a, 1963-1988.b (pers. comm., Dr. F. Serchuk, NMFS, Woods Hole, USA)

	Age											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring c																	
1968	.329	.087	1.035	.529	.426	.247	.158	.090	.053	.036	.037	3.027	2.698	2.611	1.576	1.047	.621
1969	.000	.079	.350	1.141	.569	.289	.209	.138	.082	.046	.072	2.975	2.975	2.896	2.546	1.405	.836
1970	.000	.244	.522	.308	.830	.104	.420	.176	.039	.087	.053	2.783	2.785	2.539	2.017	1.709	.879
1971	.000	.133	.525	.322	.143	.375	.091	.225	.195	.051	.112	2.172	2.172	2.039	1.514	1.192	1.049
1972	.036	1.860	1.175	1.695	.327	.076	.208	.078	.141	.074	.080	5.748	5.712	3.852	2.677	.984	.657
1973 d	.036	.334	7.464	1.403	1.628	.273	.201	.227	.032	.130	.249	11.977	11.941	11.607	4.143	2.740	1.112
1974	.000	.286	2.921	3.828	.488	1.284	.282	.065	.165	.022	.112	9.453	9.453	9.167	6.246	2.418	1.930
1975	.000	.041	.242	1.309	1.982	.167	.440	.083	.060	.069	.025	4.418	4.418	4.377	4.135	2.826	.844
1976	.071	.834	1.232	.605	.443	1.008	.105	.168	.023	.000	.035	4.524	4.453	3.619	2.387	1.782	1.339
1977	.000	.018	2.261	.692	.335	.179	.466	.033	.042	.000	.013	4.039	4.039	4.021	1.760	1.068	.733
1978	2.123	.241	.120	3.545	.621	.499	.092	.457	.033	.091	.070	7.892	5.769	5.528	5.408	1.863	1.242
1979	.070	.279	.871	.191	1.226	.347	.150	.056	.093	.008	.014	3.305	3.254	2.956	2.084	1.897	.668
1980	.067	.025	1.452	1.723	.134	.950	.383	.123	.020	.019	.071	4.967	4.890	4.865	3.413	1.690	1.556
1981	.244	1.869	1.555	2.255	1.353	.081	.706	.218	.117	.000	.069	8.467	8.223	6.354	4.799	2.544	1.191
1982 e	.120	.396	2.755	1.141	1.051	.843	.013	.242	.052	.013	.028	6.654	6.534	6.138	5.000	2.242	1.191
1983	.052	.211	1.261	1.954	.491	.447	.276	.035	.123	.000	.087	4.937	4.885	4.674	2.720	1.459	.968
1984	.000	.258	.296	.511	.744	.286	.272	.143	.000	.100	.005	2.615	2.615	2.357	2.061	1.550	.806
1985	.244	.098	2.633	.757	1.058	1.328	.270	.203	.172	.025	.150	6.938	6.694	6.596	3.963	3.206	2.148
1986	.092	.871	.423	1.824	.360	.545	.633	.063	.119	.095	.015	5.040	4.948	4.077	3.654	1.830	1.470
1987	.000	.034	1.612	.403	.752	.060	.179	.147	.016	.027	.025	3.255	3.255	3.221	1.609	1.206	.454
1988 f	(.180)	(.752)	(.664)	(3.545)	(.335)							(5.861)					
Autumn																	
1963	.012	.461	.499	.590	.575	.227	.209	.112	.066	.009	.044	2.804	2.792	2.331	1.832	1.242	.667
1964	.006	.410	.448	.377	.345	.093	.087	.040	.032	.109	.053	1.910	1.904	1.494	1.046	.669	.324
1965	.111	.833	.640	.453	.310	.107	.115	.072	.052	.015	.015	2.723	2.612	1.779	1.139	.686	.376
1966	.657	1.085	.641	.330	.169	.064	.061	.040	.025	.001	.011	3.084	2.427	1.342	.701	.371	.202
1967	.046	4.869	.855	.335	.260	.085	.085	.035	.033	.008	.045	6.656	6.610	1.741	.886	.551	.291
1968	.045	.201	1.033	.502	.174	.047	.043	.017	.015	.005	.031	2.113	2.068	1.867	.834	.332	.158
1969	.000	.220	.399	.401	.212	.060	.039	.012	.015	.014	.038	1.410	1.410	1.190	.791	.390	.178
1970	.265	1.082	.867	.336	.445	.098	.000	.021	.035	.035	.063	3.247	2.982	1.900	1.033	.697	.252
1971	.256	.386	.405	.250	.193	.305	.117	.027	.057	.000	.048	2.044	1.788	1.402	.997	.747	.554
1972	.607	4.771	.830	1.135	.256	.156	.366	.070	.131	.014	.053	8.389	7.788	3.011	2.181	1.046	.790
1973	.130	1.121	3.891	.758	1.290	.135	.145	.112	.040	.089	.161	7.872	7.742	6.621	2.730	1.972	.682
1974	.296	.262	.419	.975	.105	.073	.066	.000	.044	.000	.000	2.240	1.944	1.682	1.263	.288	.183
1975	1.524	.637	.270	.400	1.080	.072	.100	.000	.000	.000	.024	4.107	2.583	1.946	1.676	1.276	.196
1976	.000	3.941	1.328	.489	.178	.474	.035	.073	.025	.034	.013	6.690	6.690	2.749	1.421	.932	.754
1977	.123	.192	2.778	.570	.204	.141	.321	.006	.022	.000	.063	4.420	4.297	4.105	1.327	.757	.553
1978	.321	1.505	.207	3.392	.782	.272	.134	.279	.041	.024	.011	6.968	6.647	5.142	4.935	1.543	.761
1979	.096	1.314	1.393	.182	1.309	.240	.146	.029	.093	.006	.018	4.826	4.730	3.416	2.023	1.841	.532
1980	.227	.664	.458	.628	.062	.204	.043	.054	.020	.000	.000	2.360	2.133	1.469	1.011	.383	.321
1981	.212	2.860	1.826	1.265	.478	.044	.470	.046	.052	.015	.067	7.335	7.123	4.263	2.437	1.172	.694
1982	.205	.561	1.342	.141	.044	.062	.000	.010	.000	.000	.014	2.379	2.174	1.613	.271	.130	.086
1983	.661	.415	.655	.510	.035	.030	.002	.000	.008	.000	.015	2.331	1.670	1.255	.600	.090	.055
1984	.119	1.600	.065	.568	.558	.011	.040	.025	.004	.025	.028	3.043	2.924	1.324	1.259	.691	.133
1985	1.084	.220	.803	.103	.115	.101	.000	.000	.004	.000	.000	2.430	1.346	1.126	.323	.220	.105
1986	.096	2.280	.153	.382	.010	.061	.090	.016	.000	.008	.028	3.124	3.028	.748	.595	.213	.203
1987	.204	.414	1.353	.112	.195	.028	.012	.000	.000	.007	.000	2.325	2.121	1.707	.354	.242	.047
1988	.550	.903	.433	.909	.091	.178	.000	.011	.039	.000	.000	3.113	2.563	1.660	1.227	.318	.227

a. Spring and autumn cover USA strata 13-25

b. Catch per tow at age for 1963-69 obtained by applying 1970-81 age-length keys to stratified mean catch per tow at length distributions from each survey.

c. Spring surveys during 1973-81 were accomplished with a "Yankee 41" trawl. In all other years, spring surveys were accomplished with a "Yankee 36" trawl. No adjustments have been made for these gear differences.

d. Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4)

e. Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7)

f. Preliminary estimate from length distribution

Table 10(a). Proportional distribution of cod by USA strata derived from USA spring surveys.

Stratum	1970	1971	1972	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Mean
								Year									
								BIOMASS									
13	0.089	0.072	0.088	0.094	0.075	0.057	0.076	0.097	0.111	0.021	0.090	0.006	0.011	0.038	0.047	0.111	0.068
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.298	0.329	0.275	0.416	0.143	0.150	0.130	0.228	0.337	0.462	0.206	0.885	0.221	0.131	0.395	0.267	0.305
17	0.010	0.011	0.002	0.002	0.009	0.025	0.009	0.013	0.014	0.014	0.016	0.001	0.028	0.013	0.003	0.006	0.011
18	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.005	0.005	0.000	0.003	0.003	0.000	0.003	0.000	0.001
19	0.187	0.269	0.260	0.220	0.240	0.308	0.186	0.290	0.113	0.244	0.238	0.010	0.176	0.206	0.181	0.135	0.204
20	0.078	0.110	0.093	0.075	0.369	0.191	0.237	0.057	0.102	0.063	0.197	0.056	0.285	0.287	0.184	0.111	0.156
21	0.014	0.020	0.038	0.029	0.009	0.033	0.146	0.057	0.090	0.024	0.037	0.003	0.026	0.013	0.055	0.066	0.041
22	0.010	0.000	0.015	0.006	0.006	0.016	0.016	0.121	0.024	0.021	0.036	0.007	0.018	0.043	0.035	0.034	0.025
23	0.124	0.059	0.124	0.097	0.042	0.150	0.120	0.069	0.054	0.063	0.047	0.004	0.134	0.028	0.030	0.149	0.081
24	0.174	0.101	0.053	0.021	0.078	0.051	0.058	0.047	0.093	0.076	0.106	0.019	0.076	0.169	0.040	0.082	0.078
25	0.016	0.030	0.054	0.040	0.029	0.021	0.023	0.018	0.056	0.006	0.026	0.007	0.023	0.072	0.026	0.038	0.030
								NUMBERS									
13	0.087	0.079	0.181	0.064	0.059	0.057	0.087	0.206	0.121	0.031	0.078	0.008	0.018	0.059	0.084	0.099	0.082
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.364	0.269	0.267	0.468	0.124	0.129	0.093	0.125	0.288	0.506	0.208	0.811	0.146	0.127	0.339	0.184	0.278
17	0.015	0.013	0.003	0.003	0.012	0.038	0.006	0.015	0.019	0.017	0.011	0.002	0.033	0.032	0.012	0.003	0.015
18	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.005	0.003	0.000	0.002	0.005	0.000	0.005	0.001	0.002
19	0.223	0.213	0.286	0.208	0.295	0.358	0.283	0.372	0.111	0.263	0.255	0.024	0.132	0.188	0.207	0.156	0.224
20	0.063	0.141	0.063	0.076	0.361	0.165	0.221	0.067	0.110	0.061	0.237	0.087	0.356	0.219	0.184	0.186	0.162
21	0.015	0.092	0.042	0.030	0.009	0.023	0.107	0.038	0.160	0.020	0.043	0.004	0.040	0.036	0.049	0.098	0.050
22	0.005	0.000	0.012	0.002	0.005	0.005	0.008	0.069	0.014	0.015	0.011	0.013	0.009	0.024	0.016	0.018	0.014
23	0.096	0.122	0.058	0.098	0.045	0.174	0.112	0.064	0.050	0.053	0.027	0.006	0.168	0.048	0.039	0.088	0.078
24	0.111	0.044	0.034	0.009	0.051	0.031	0.042	0.018	0.044	0.016	0.075	0.017	0.044	0.102	0.019	0.096	0.047
25	0.021	0.026	0.053	0.041	0.039	0.019	0.042	0.024	0.079	0.012	0.055	0.026	0.049	0.165	0.045	0.070	0.048

Table 10(b). Proportional distribution of cod by USA strata derived from USA fall surveys.

Stratum	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1982	1983	1984	1985	1986	Mean
								Year									
								NUMBERS									
13	0.000	0.000	0.002	0.002	0.046	0.000	0.000	0.004	0.011	0.002	0.000	0.000	0.000	0.012	0.007	0.038	0.008
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.059	0.130	0.238	0.153	0.065	0.142	0.359	0.160	0.234	0.417	0.145	0.038	0.017	0.334	0.310	0.244	0.190
17	0.000	0.043	0.014	0.031	0.000	0.012	0.001	0.030	0.015	0.008	0.145	0.037	0.005	0.065	0.022	0.030	0.029
18	0.007	0.000	0.000	0.005	0.005	0.004	0.002	0.000	0.008	0.028	0.002	0.000	0.002	0.020	0.003	0.006	0.006
19	0.147	0.113	0.002	0.034	0.016	0.009	0.005	0.026	0.077	0.050	0.046	0.000	0.000	0.012	0.089	0.000	0.039
20	0.450	0.208	0.029	0.181	0.101	0.062	0.033	0.188	0.026	0.066	0.094	0.113	0.015	0.094	0.006	0.034	0.106
21	0.095	0.034	0.044	0.063	0.208	0.046	0.179	0.180	0.075	0.072	0.100	0.112	0.134	0.051	0.262	0.463	0.132
22	0.020	0.026	0.007	0.009	0.000	0.004	0.003	0.015	0.052	0.027	0.083	0.021	0.002	0.000	0.000	0.000	0.017
23	0.105	0.078	0.302	0.246	0.214	0.521	0.065	0.145	0.105	0.094	0.073	0.041	0.141	0.326	0.058	0.024	0.159
24	0.090	0.258	0.063	0.162	0.100	0.088	0.325	0.142	0.220	0.157	0.098	0.551	0.024	0.057	0.126	0.154	0.163
25	0.027	0.109	0.298	0.113	0.245	0.115	0.029	0.110	0.175	0.081	0.214	0.087	0.660	0.029	0.118	0.007	0.151

Table 11. Stratified mean catch per tow at age (numbers) of Atlantic cod in Canadian spring trawl surveys on Georges Bank, 1986-89.

	Age											Totals				
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
1986	.00	.66	2.67	3.06	.40	.67	.45	.26	.05	.09	.03	8.34	8.34	7.68	5.01	1.95	1.55
1987	.00	.25	2.13	.93	1.09	.34	.12	.22	.08	.03	.07	5.25	5.25	5.00	2.87	1.94	.85
1988	.00	.28	1.01	4.65	.58	1.02	.13	.08	.17	.04	.06	8.02	8.02	7.74	6.73	2.08	1.50
1989	.00	1.66	2.82	1.40	2.86	.36	.41	.05	.09	.12	.06	9.83	9.83	8.17	5.35	3.95	1.09

Table 12. Summary of commercial C/E derived from a multiplicative analysis of USA and Canadian catch and effort (t/hr) in unit areas 5Zj and 5Zm.

Year	Canada	Canada	USA
1967	0.509	-	-
68	0.544	-	-
69	0.467	-	-
1970	0.329	-	-
71	0.326	-	-
72	0.341	-	-
73	0.372	-	-
74	0.312	-	-
75	0.395	-	-
76	0.284	-	-
77	0.860	-	-
78	0.875	1.076	-
79	0.719	0.909	0.218
1980	0.563	0.657	0.231
81	0.700	0.833	0.226
82	0.792	0.903	0.229
83	0.514	0.581	0.199
84	0.472	0.548	0.144
85	0.771	0.795	0.137
86	0.585	0.678	0.141
87	0.524	0.577	0.104
88	0.570	-	-

Figure 1. Canadian cod catch by gear in 5Zj and 5Zm, 1978-88

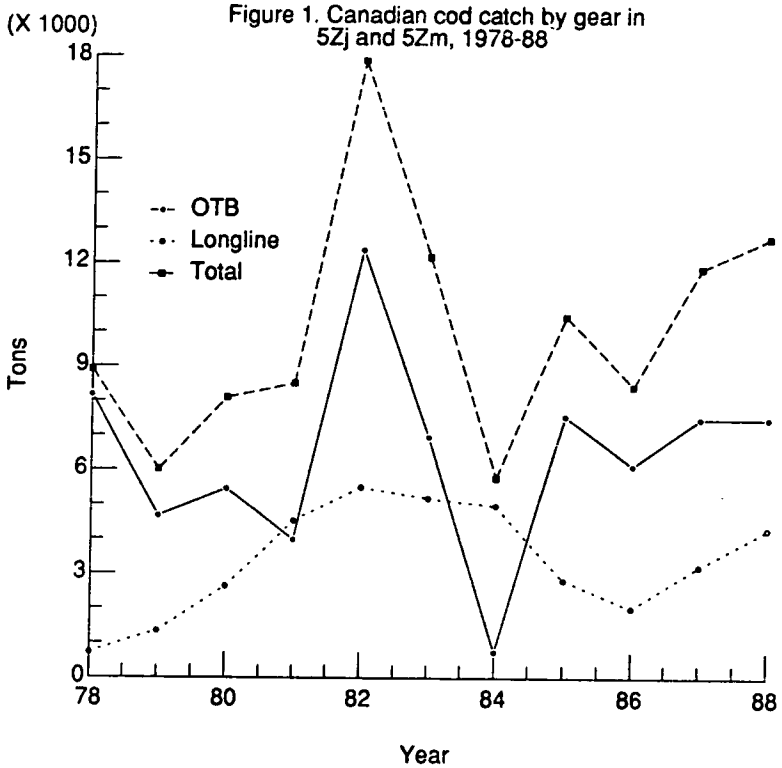


Figure 2. Canadian and USA cod catch in 5Zj and 5Zm, 1978-88

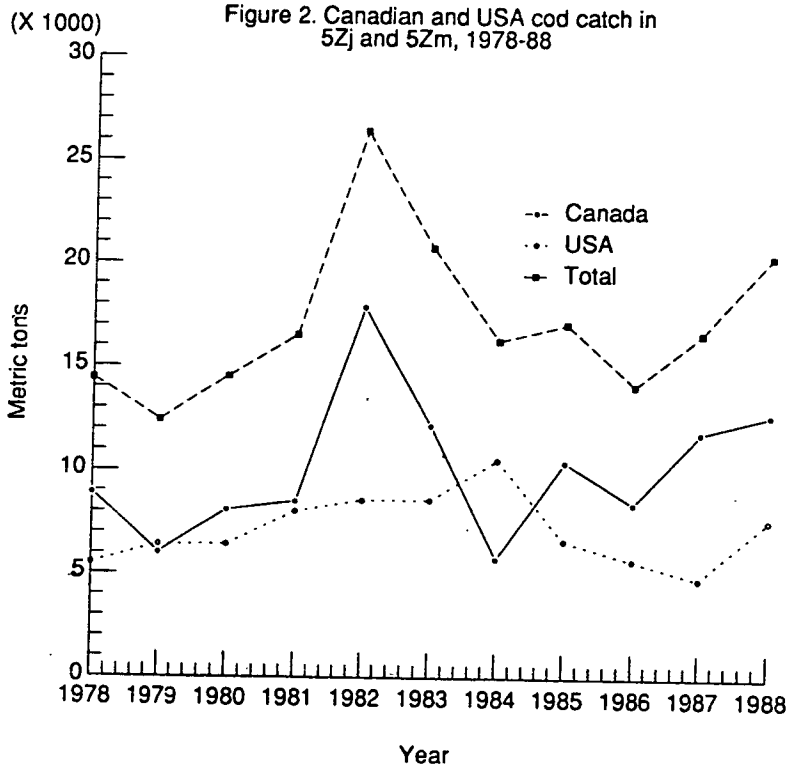


Figure 3. Comparison of Canadian and USA OTB length frequencies in 1988.

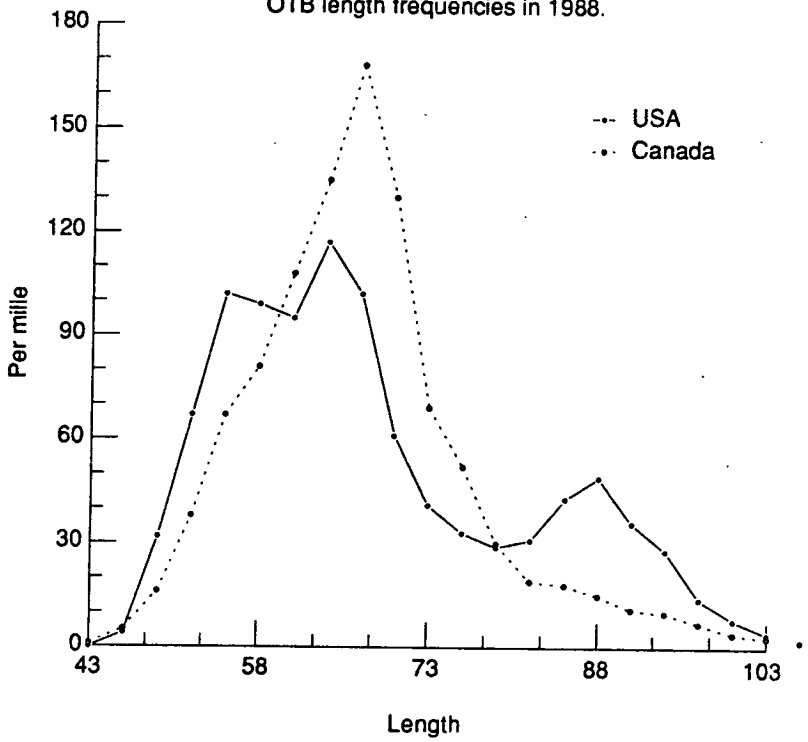


Figure 4. USA fall and Canadian spring survey catch per tow in 5Z.

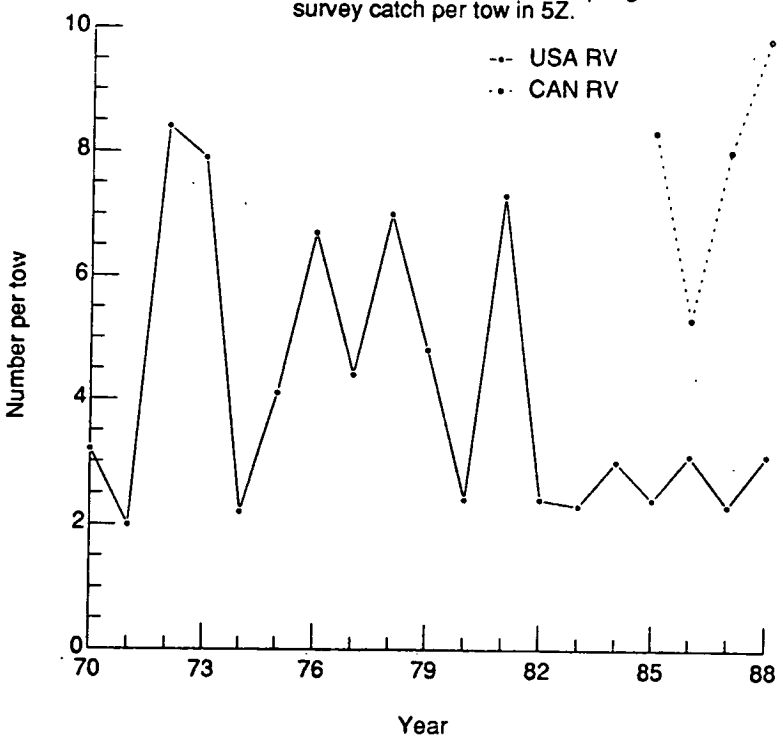


Figure 5. Canadian (67-88 and 78-87) and USA C/E in 5Zj and 5Zm.

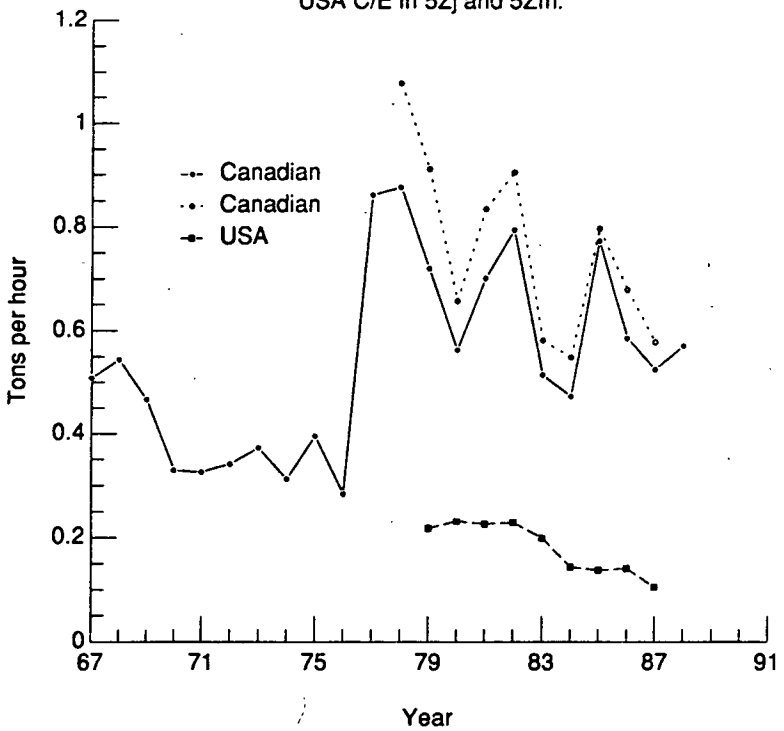
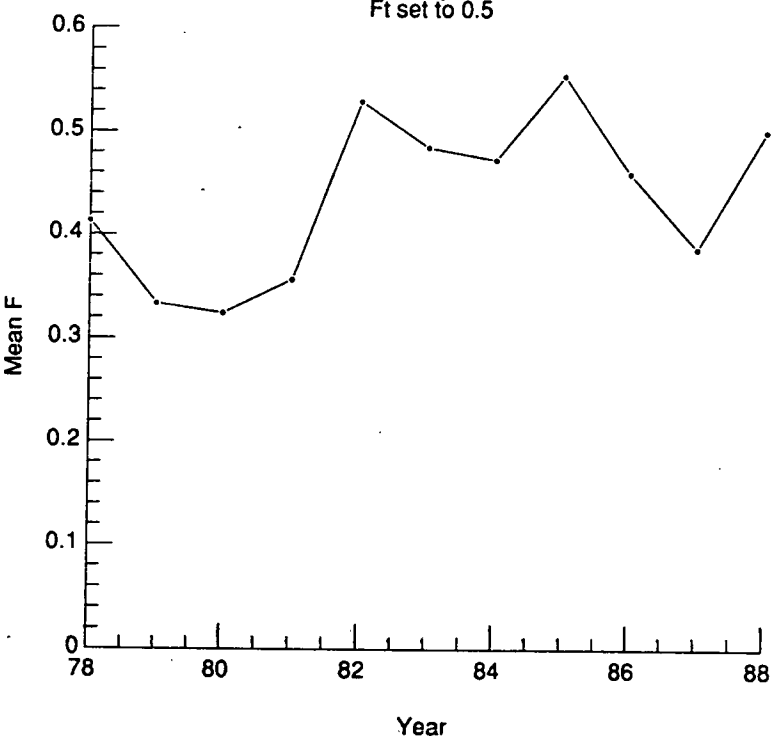


Figure 6. Mean fully recruited F with Ft set to 0.5



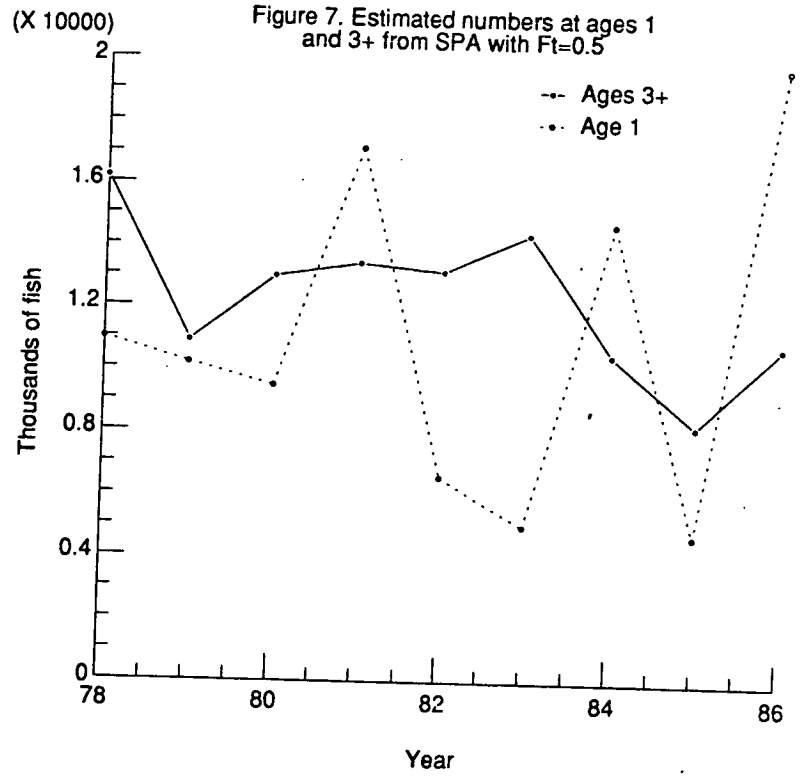


Figure 7. Estimated numbers at ages 1 and 3+ from SPA with Ft=0.5

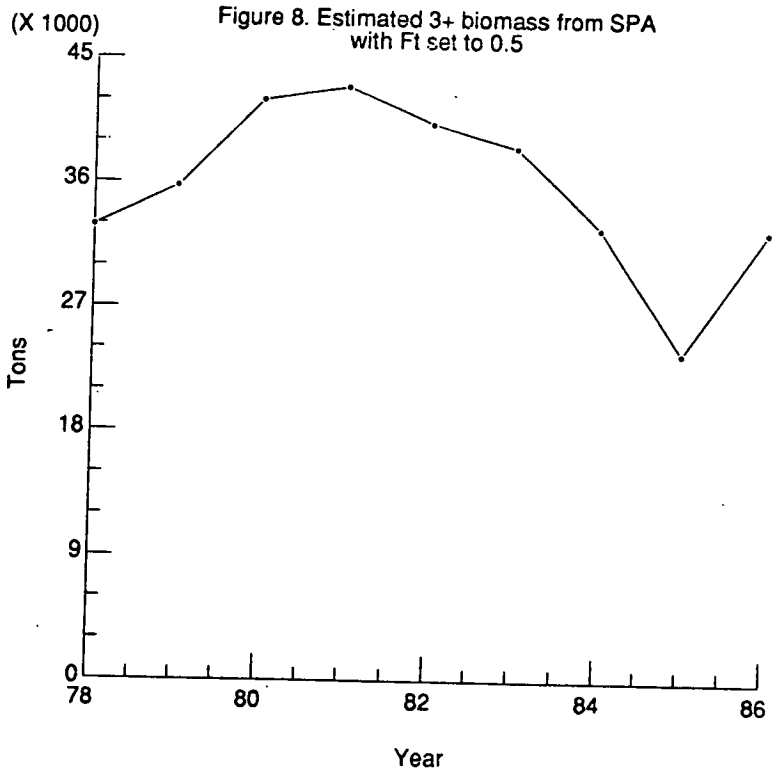


Figure 8. Estimated 3+ biomass from SPA with Ft set to 0.5

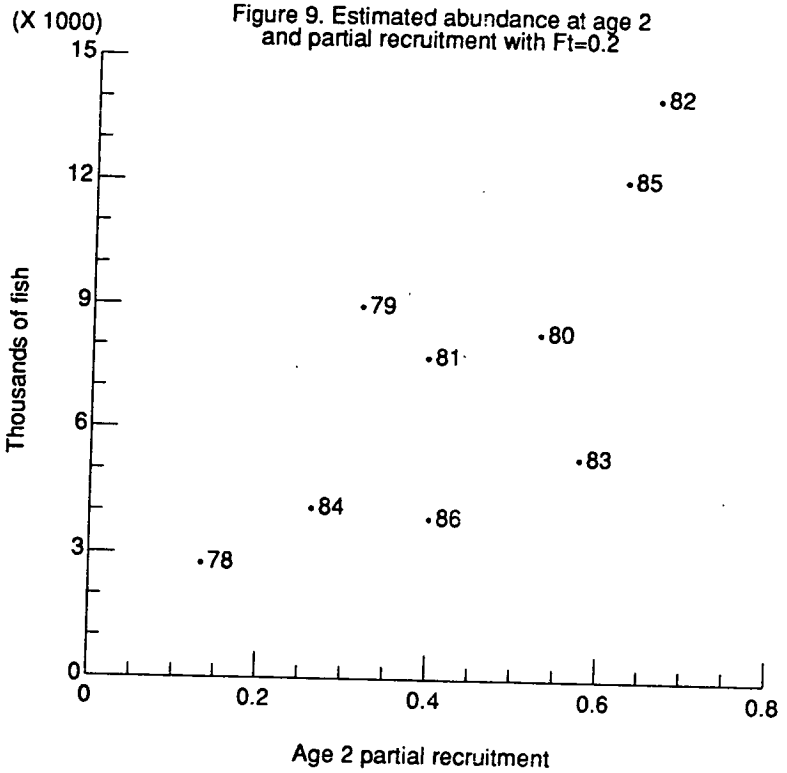


Figure 9. Estimated abundance at age 2 and partial recruitment with Ft=0.2

APPENDIX I

Report of MFD Special Meeting on the Groundfish Management Units in the Gulf of Maine Area

Conference Room
Biological Station
St. Andrews, N.B.

12 April 1989

Introduction

The Canadian fisheries management system currently incorporates the Canadian part of Subdiv. 5Ze (i.e. Subdiv. 5Zc) in the following management units for cod, haddock and pollock:

Cod	Divisions 5Z-6
Haddock	Subarea 5
Pollock	Divisions 4VWX + 5

The rationale for these was established in the ICNAF era. Since then, the establishment of domestic management systems in both Canada and the USA (1977) coupled with definition of a new international boundary (1984) has created the need for a re-examination of the management unit definition. A review of these was conducted under the auspices of CAFSAC in 1986. Although a number of modifications to management unit boundaries appeared possible, the process was not completed. More information is now available from tagging experiments and was examined along with previous results. A meeting of MFD staff was held in St. Andrews on 12 April 1989 to consider the available data, historical and current, relevant to the cod, haddock and pollock management units. This report summarizes the findings and rationale used in arriving at them.

Georges Bank Cod

Canadian landings from NAFO Div. 5Ze are reported historically from unit area 5ZeJ and 5Zem with over 90% of the catch coming from the North East peak in recent years (Figure 1). About 70% of the USA 5Ze catch is taken in unit areas 5Zeg, 5Zeh, 5Zen and 5Zeo with over 40% in 5Zeg alone. There is definite evidence for a discontinuity in the landings from the Bank between these four unit areas in the west and the two unit areas on the North East peak in the east. Canadian catch in 4X is spread across the entire division with substantial catches in 4Xp (Browns Bank).

Canadian and USA research surveys of 5Ze indicate widespread distribution of cod over the area. However, two centres of abundance are apparent with one in the 5Zej,m area and the other in the South Channel area. Annual and seasonal variation in the distributions occurs with more dense aggregations in 5Zej,m in the late winter period. These results indicate that a variable

proportion of the 5Ze population is found in the Canadian zone which requires further study.

Analysis of tagging data collected in the early 1960s suggests the presence of four groups of cod - offshore 4X/5Z (Browns and Georges banks), inner Gulf of Maine, New England/South Channel and finally New Jersey. Little interaction between the Georges Bank group and that to the west of the South Channel is evident.

These findings are confirmed and amplified by more recent work conducted in 1979-87. Results indicate that most fish released in 4X were recovered in 4X with widespread movement between unit areas. Limited movement to the North East peak of Georges Bank (5Zej) was also evident. The majority of the tags released in 5Zej were recovered in 5Zej and 5Zem with little movement to the west. This is in agreement with previous tagging studies. Movement to 4X (primarily Browns Bank) was also evident. Quantification of the extent of these movements will require further analysis, however, it is not expected that this will change the conclusions.

Sufficient differences exist in growth rates between Georges and Browns banks to preclude treating them with one management strategy.

There are a number of centres of spawning in the Gulf of Maine area. Based on distributions of eggs, larvae and juveniles it is apparent that spawning occurs on Browns Bank, northeast part of Georges Bank, along the New England coast and in the Cape Cod areas.

In summary, the examination of the data collected to date suggests that the 5Z+6 management unit should be divided into two as follows:

1. Unit areas 5Zej and 5Zem

2. Unit areas 5Zeg, 5Zeo, 5Zeh and 5Zen plus areas to the south in 5ZW and Subarea 6.

There is insufficient evidence at this time to associate 5Zej cod with those in 4X. The separation of Management Unit 5Z+6 into two components, one on the northeast peak of Georges Bank and the other in the South Channel and west, has implications for management of the resource. Movement of cod across the International Boundary occurs, and it would be inappropriate to consider this line as a boundary for stock separation without quantifying the degree of movement. It is planned to conduct further research on the degree of movement both within 5Ze and between it and 4X. However, most of the cod associated with the northeast peak of Georges Bank are contained within unit areas 5Zej,m and it is, therefore, recommended that these two areas be used for the management of the resource.

Figure 1. Unit Areas and NAFO Div./Subdiv.