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Biological Update of Georges Bank Cod in Unit Areas 5Zj,m for 1978-92

by

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Abstract

Total landings for cod in Div.5Zj,m in 1992 were 16792 t, about equal to the long term average of 17000 t. Canadian landings decreased by about 2000 t from 1991 and USA landings were the lowest since 1987. The 1990 year class (age 2) was dominant (44% in numbers) in Canadian landings. Size at age for Canadian samples shows an increase over long term averages. The most recent Canadian and USA spring surveys show a decline in mean catch per tow, and the USA fall survey, while showing a slight increase in 1992, is anomalously low. Vessel and door conversion factors were applied to USA surveys. A catch rate standardization for Canadian OTB using 'index' vessels indicates a substantial decline in CPUE since 1990 which is consistent with other indices of abundance. Results of an ADAPT analysis indicate a substantial decline in abundance since 1989. Exploitation rates have increased from about F_{max}=0.4 in 1989 to about four times $F_{0.1}$ in 1992. Results of a study to assess distribution and migration of cod relative to the Canadian/USA boundary indicate substantial but reciprocal movement of cod in 5Zj,m. Further work is required to determine the impact of movement on management options.

Résumé

Les débarquements totaux de morue provenant des divisions 5Zj,m se sont établis à 16 792 t en 1992, ce qui correspond à peu près à la moyenne à long terme (17 000 t). Les débarquements canadiens ont diminué d'environ 2 000 t par rapport à 1991 et ceux des États-Unis étaient à leur plus bas depuis 1987. La classe d'âge de 1990 (âge 2) dominait (44 %) dans les débarquements canadiens. Dans les échantillons canadiens, la grandeur selon l'âge était supérieure aux moyennes à long terme. Les plus récents relevés de recherche de printemps canadiens et américains indiquent une diminution des prises moyennes par trait, tandis que le relevé de recherche d'automne réalisé par les États-Unis est anormalement bas, quoiqu'il révèle une légère hausse pour 1992. Des facteurs de conversion des bateaux et des panneaux ont été appliqués aux relevés de recherche américains. La normalisation des taux de prises des bateaux canadiens pêchant au chalut à panneaux, réalisée au moyen de bateaux-repères, dénote une baisse notable des PUE depuis 1990, ce qui correspond aux autres indices d'abondance. Les résultats d'une analyse ADAPT révèlent une importante diminution de l'abondance depuis 1989. Les taux d'exploitation sont passés d'environ F_{max} = 0,4 en 1989 à approximativement quatre fois $F_{0,1}$ en 1992. Selon une étude de la distribution et des migrations de la morue par rapport à la frontière canado-américaine, les mouvements de morue dans 5Zj,m sont importants, mais réciproques. D'autres études sont nécessaires pour déterminer les effets de ces mouvements sur les diverses méthodes de gestion.

Introduction

This report incorporates commercial catch data and research survey results to estimate stock status of cod for the 1978-92 time period in the two unit areas 5Zj,m (Figure 1). Definition of this management unit was based on analysis of tagging results as well as commercial and survey catch distribution and more recent tagging studies (Hunt, 1990).

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

Trends in Reported Landings

Catches by the USA in unit areas 5Zj and 5Zm are thought to be mis-reported with extensive discarding prior to 1978 (Serchuk and Wood, 1981) and estimates of population status prior to this time are suspect. 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. As well, the spatial distribution of foreign fleet catches in Subdiv. 5Ze are unknown and could therefore not be allocated to the 5Zj,m area. There have been no reported landings by foreign fleets since 1978.

Fishery by Country and Gear

Canadian catches of cod are taken on the "Northeast Peak" of Georges Bank primarily between April and November and have been limited to the Canadian side of the international boundary since 1985. Landings have been dominated by otter trawlers, except in 1984 and 1989 (Table 1, Fig. 2). However, in recent years the proportion of total landings taken by fixed gears (longline and gillnet) have increased. The below average 1989 catch by otter trawlers reflects early closure of the fishery when the combined quota for Div. 4X+5 was exceeded.

In 1990, a 6000 t increase over 1989 in Canadian landings was the result of a return to historic catches by the OTB fleet and resulted in an overall catch of 14310 t, the second highest in the time series. Canadian landings in 1991 were 13455 t but decreased to 11712 t in 1992. USA landings in 1992 were 5080 t, well below the average (6500 t) for recent years. Management of the Canadian fishery since 1990 has been by individual and equal boat quotas of 280000 lb with by-catch restrictions.

Catches by Canada and the USA in unit areas 5Zj and 5Zm for 1978-92 are summarized in Table 2 and in Figure 3. Combined catches peaked at 26000 t in 1982, averaged about 15000 t between 1983-87 and increased to 20000 t in 1988. The reduction in 1989 to 14000 t was a result of decreased mobile gear catch by both Canada and the USA. Landings in 1992 were about 3000 t less than the 1990 and 1991 landings. Since 1985, Canada has taken about 65% of the total catch.

Seasonal differences in landings for the USA and Canadian fishery in the 1985-92 time period are shown in Figures 4 and 5. The USA fishery typically is concentrated in the first half of the year while the opposite is true for the Canadian fishery. There has been some shift in the USA fishery towards the second quarter in recent years.

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. 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. Since 1985 sampling has increased and in 1992, 48 samples were collected. A summary of sampling data is given in Table 3. Combinations of length and age samples used to estimate the 1992 catch at age for Canada and USA are shown in Table 4. Note that age length keys (ALK) combined by gear type within quarter were used to estimate Canadian catch at age. This is in contrast to earlier years when ALK by gear type were used. The change is based on results of a study which concluded that no significant difference in probability of age at length exists between gears (Hunt, 1992)

Age Composition

A length-weight relationship derived from Canadian commercial sampling data was used. With round weight in kilograms and length in centimetres, weight (kg)=0.0000163 x length$^{2.9048}$, and was used for both Canadian and USA sampling data.

Estimated total removals at age are given in Table 5 by country for 1978-91 and for Canada in 1992. USA sampling and landings were not available for analysis. Canadian landings of 5Zj,m cod were dominated by the 1990 year class at age two (44%) in 1992. Catch at age two in 1992 was the highest since 1987 when the strong 1985 year class was entering the fishery (Table 6).

Mean length and weight at age for Canadian samples are given in Table 7. The 10+ age group was set to 115 cm and 15 kg, the approximate mean for ages 10-15. There appears to be no trend in size or weight at age over the 12 year time series, although mean weights at age in 1990-92 appear to be above the long term average.

Exchange of otolith samples between Canada and USA show good agreement (82%). Ongoing studies of Georges Bank cod otolith characteristics continue to increase accuracy of age determinations. Neilson et al (1991) compare Canadian and USA catch at age estimates.

Stock Abundance Trends

Research Surveys

Hunt et al (1991) describe the approach used to estimate mean catch per tow specific to the 5Zj,m area for Canadian and USA surveys. The technique required selecting only sets within the 5Zj,m boundary and using strata areas also within the 5Zj,m boundary. They also document the vessel and gear conversion factors used to adjust results of the USA surveys to RV Albatross IV equivalents. The 1992 spring and fall USA surveys were conducted with the Albatross and therefore did not require adjustment.

Results of analysis for each of the surveys are given in Table 8. The 1982 USA spring survey is influenced by one tow of 1000 fish and the resultant high catch rate has a high standard error. This tow has been excluded by USA researchers in their analyses (Anon, 1992). Examination of tows in the 1982 survey indicates above average catches in several sets and strata and therefore all tows were included in the present study. Age data were not available for the 1992 USA fall survey and therefore catch per tow at age was estimated using an age key derived from the combined 1990-91 fall surveys.

Total catch per tow has been variable for each of the surveys. The 1991 and 1992 Canadian surveys show a marked decline from the high 1990 value and the decline continues in 1993. The 1991 USA fall survey catch per tow is the lowest on record. A slight recovery in the fall of 1992 still results in the second lowest estimate in the series. The 1992 USA spring is at the lowest observed value. The three surveys for ages 1-9, standardized to their maximum and excluding the USA spring 1982 survey, are summarized in Figure 6.

The fall survey is assumed to be a post-fishery index and spring surveys are assumed to be a pre-fishery index. Therefore, the fall survey is lagged by one year for comparison of indices (ie. fall 1977 age one vs spring 1978 age two). In general, all three surveys appear to track year class strength and provide a consistent index. The 1987 year class, which will be a substantial factor in the 1990-93 fishery, appears to be above average in the Canadian and USA spring surveys in 1989-91. The 1990 year class also appears to be above average in all three of the 1992 surveys but the 1991 year class appears to be below average.

Commercial Catch Rates

A study of commercial C/E for Canadian OTB's (Hanke, 1993) concludes that effort has increased since 1989 and that catch rates have declined substantially. This is in contrast to analyses in 1991 which concluded that effort in 1991 was similar to that of 1990. Population estimates derived in 1992 (Hunt and Buzeta, 1992) may, therefore, be representative of the status of the stock.

Prognosis

An ADAPT run using the same formulation as in the 1992 assessment was completed. Results are given in Table 9 for estimates of population numbers, biomass and fishing mortality and plotted in Figure 7. Parameter estimates and their associated measures of precision are given in Table 10 and survey indices residuals in Table 11. The relative error for population estimates are very high (46-67%) although the relative error for survey indices is lower (11-35%). As was noted in last year's assessment, a strong annual pattern exists in residuals for survey indices. While the absolute values of estimates are subject to assumptions and poor precision, the relative estimates are probably indicative of population trends and confirm the substantial increase in exploitation rate and decline in abundance since 1989.

The analytical assessment of stock is subject to poor precision and therefore estimates of abundance and catch projections are also imprecise. Catch projections for 1993 were completed with the following input parameters:

Age	1993 Population Numbers (000's)[1]	Mean Weight (kg) 1992	Partial Recruitment
1	2400[2]	0.696	0.004
2	1741	1.391	0.32
3	5444	2.249	1.00
4	878	3.579	1.00
5	157	5.012	1.00
6	297	6.448	1.00
7	127	8.333	1.00
8	294	10.34	1.00
9	48	10.95	1.00
10+	20	15.00	1.00

[1] adjusted for bias
[2] Assumed equal the lowest observed

Two options were considered for 1993 - a catch equal the Canadian quota plus expected USA catches and a combined USA and Canadian catch at $F_{0.1}$ and the resultant 1994 catches at $F_{0.1}$. Results are shown below:

Option	1993 F3+	1993 catch[1]	Beginning of 1994 SSB (3+)	Beginning of 1994 1+ Biomass	1994 Catch[1] at $F_{0.1}$
$F_{0.1}$	0.2	3,900 t	20,568 t	26,438 t	4,260 t
Assumed 1993 Catch[1]	1.4	17,000	6,970	12,830	1,560

[1] total Canadian and USA catch

There are a number of concerns about the exploitation rates which this stock has experienced in recent years. There is little doubt that fishing mortalities in the 1990's are well above $F_{0.1}$ and could have exceeded F_{max} by a factor of two or more. The fishery, in particular the mobile gear sector, is largely dependent on recruitment. This can result in substantial mortality at age two and, since fish at this age are up to 50% immature, a substantial loss in spawning potential for recruiting cohorts.

Indices of abundance derived from research surveys indicate a continuing decline in 1992 and are now at very low levels. The March 1993 Canadian survey suggests that abundance is now less than 40% of its maximum observed value (1990). Spawning stock biomass, represented by the 3+ population, appears to be at very low levels and the 1992 and 1993 estimates are the lowest observed since 1978.

Canadian 1993 Fishery

A change occurred in the 1993 fishery when the Canadian <65' OTB fishery was opened at the beginning of January. Landings to March 31, 1993 are estimated to be close to 2000 t with about 1500 t by OTB. Length frequency samples of first quarter 1993 landings are compared with those of those of the 1992 fourth quarter in Figure 8. Substantial differences between the two length distributions are apparent. In 1993 the OTB landings continued to be dominated by the 1990 year class with a mode at about 55 cm. However, a large proportion of landings were of fish >70 cm. This may indicate a change in availability of large fish to the OTB fleet during spawning aggregations. Hunt (unpublished data) describes the length and maturity composition of the Georges Bank cod stock.

Management Considerations

Management of this resource in recent years has not been based on recommended catch quotas and introduction of ITQ's in 1992 and 1993 for the OTB fleet may have changed exploitation patterns. In 1993 the OTB fleet was allowed to fish during the spawning season. Exploitation rates have increased and spawning stock biomass (3+) is much lower than the average and may be at its lowest level. The fishery is mostly recruitment driven and recruitment has been variable and appears to be poor for 1993 and 1994. Total catches in 1993 and 1994 of the same magnitude as taken in 1991/92 (15-20000 t) could result in fishing mortalities in excess of 1.0 and would result in a further reduction in stock biomass.

An immediate and substantial reduction in exploitation rates for both Canada and the USA is required if the decline in stock biomass is to be slowed or reversed. Distribution and migration studies suggest that the proportion of the total stock outside the Canadian zone would limit the results of unilateral management action by Canada due loss of biomass to the USA zone through migration and potential harvesting by the USA. Consistent management objectives by the USA and Canada are required for the total stock.

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Table 1. Nominal landings (t) of cod by gear and month for Canada in unit areas 5Zjm. :(OT-otter trawl;LL-longline;GN-gillnet;MISC-miscellaneous).

YEAR	GEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
78	OT	166	762	187	26	304	1808	1095	75	219	1633	1487	0	7762
	LL	0	0	0	0	10	308	241	77	74	19	0	0	729
	MISC	0	0	55	1	0	17	102	0	0	14	98	0	287
	TOT	166	762	242	27	314	2133	1438	152	293	1666	1585	0	8778
79	OT	72	302	178	78	74	1634	649	674	648	293	28	7	4637
	LL	0	0	0	5	20	529	334	306	134	10	0	0	1338
	MISC	0	0	1	1	1	0	0	0	0	0	0	0	3
	TOT	72	302	179	84	95	2163	983	980	782	303	28	7	5978
80	OT	24	86	3	52	111	1373	1593	771	633	591	68	100	5405
	LL	0	0	0	0	208	951	596	496	337	47	0	0	2635
	MISC	0	0	1	2	1	2	1	16	0	0	0	0	23
	TOT	24	86	4	54	320	2326	2190	1283	970	638	68	100	8063
81	OT	2	205	55	7	38	529	1005	744	1013	36	229	97	3960
	LL	0	0	1	2	538	1476	1044	837	284	281	57	5	4525
	MISC	0	0	0	1	0	12	0	0	1	0	0	0	14
	TOT	2	205	56	10	576	2017	2049	1581	1298	317	286	102	8499
82	OT	90	73	0	0	11	845	4289	2109	1507	2360	934	119	12337
	LL	0	11	26	193	772	1035	1388	1082	635	308	33	4	5487
	MISC	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOT	90	84	26	193	783	1880	5677	3191	2142	2668	967	123	17824
83	OT	179	41	9	6	35	2209	1095	2115	956	171	76	11	6903
	GN	0	0	0	0	0	4	8	3	5	0	0	0	20
	LL	0	0	171	147	440	1440	698	574	1303	311	89	0	5173
	MISC	0	0	0	0	0	5	28	0	0	1	0	0	34
	TOT	179	41	180	153	475	3658	1829	2692	2264	483	165	11	12130
84	OT	5	3	13	0	37	267	92	240	60	19	0	0	736
	GN	0	0	0	0	0	34	3	0	0	0	0	0	37
	LL	0	0	167	152	112	1193	1209	1183	605	286	50	0	4957
	MISC	0	0	0	1	3	21	7	1	0	0	0	0	33
	TOT	5	3	180	153	152	1515	1311	1424	665	305	50	0	5763
85	OT	0	2	0	0	0	1336	2565	2440	693	435	5	80	7556
	GN	0	0	0	0	0	14	4	9	0	0	0	0	27
	LL	0	29	54	181	151	414	230	540	647	501	29	29	2805
	MISC	0	1	2	14	15	6	9	2	3	2	0	1	55
	TOT	0	32	56	195	166	1770	2808	2991	1343	938	34	110	10443
86	OT	14	9	0	15	6	2364	3138	477	49	11	4	22	6109
	GN	0	0	0	0	0	44	82	75	29	0	0	0	230
	LL	0	58	86	12	24	146	120	538	606	409	12	0	2011
	MISC	0	2	9	15	10	3	7	1	14	0	0	0	61
	TOT	14	69	95	42	40	2557	3347	1091	698	420	16	22	8411
87	OT	19	1	3	0	0	2485	3941	890	145	2	78	44	7608
	GN	0	0	0	0	0	109	249	308	38	0	0	0	704
	LL	0	6	112	68	8	293	591	1032	747	310	12	33	3212
	MISC	5	11	15	17	9	33	88	82	51	2	6	2	321
	TOT	24	18	130	85	17	2920	4869	2312	981	314	96	79	11845
88	OT	23	520	56	0	13	3247	3181	428	17	98	29	8	7620
	GN	0	0	0	0	0	180	224	141	50	21	0	0	616
	LL	54	86	68	205	27	1247	1685	392	426	134	10	1	4335
	MISC	2	9	12	10	16	41	95	97	53	0	20	2	357
	TOT	79	615	136	215	56	4715	5185	1058	546	253	59	11	12928
89	OT	5	140	7	0	2	1553	86	70	2	87	33	2	1987
	GN	0	0	0	0	0	131	359	440	175	9	0	0	1114
	LL	41	202	250	92	268	909	1057	1210	331	65	0	0	4425
	MISC	7	7	9	22	47	126	85	151	15	3	3	0	475
	TOT	53	349	266	114	317	2719	1587	1871	523	164	36	2	8001
90	OT	0	0	0	0	1	3187	1744	1547	929	436	9	1	7854
	GN	0	0	0	0	0	114	344	309	143	0	0	0	910
	LL	125	149	260	0	129	1156	1448	1098	581	252	4	0	5202
	MISC	6	12	19	19	10	62	77	58	63	5	11	2	344
	TOT	131	161	279	19	140	4519	3613	3012	1716	693	24	3	14310
91	OT	348	33	22	1	0	3455	1536	672	316	296	14	6	6698
	GN	0	0	0	0	17	427	696	364	163	20	0	0	1688
	LL	49	335	187	230	202	597	1028	860	699	363	113	43	4706
	MISC	8	8	7	25	15	59	71	104	51	6	9	0	363
	TOT	405	376	216	256	234	4538	3331	2000	1229	685	136	49	13455
92	OT	261	375	0	1	12	2835	972	287	214	541	132	9	5638
	GN	0	0	0	0	1	294	350	342	203	26	2	0	1217
	LL	114	340	475	275	237	799	676	612	509	337	101	0	4474
	MISC	9	13	19	21	24	141	75	47	0	4	8	1	383
	TOT	384	726	494	296	274	4068	2073	1287	945	909	243	10	11712

Table 2.Summary of total catches (t) by Canada and the USA in unit areas 5Zjm for 1978-1992.

YEAR	CANADA	USA	TOTAL
1978	8778	5502	14280
1979	5978	6408	12386
1980	8063	6418	14481
1981	8499	8094	16593
1982	17824	8565	26389
1983	12130	8572	20702
1984	5763	10551	16314
1985	10443	6641	17084
1986	8411	5696	14107
1987	11845	4792	16637
1988	12932	7645	20577
1989	8001	6182	14183
1990*	14310	6378	20688
1991*	13455	6777	20232
1992*	11712	5080	16792

* preliminary

Table 3. Canadian and USA commercial landings samples for 1978-92.

	USA			Canada		
	Samples	Lengths	Ages	Samples	Lengths	Ages
1978	29	2047	385	29	7684	1308
79	21	1833	402	13	3991	656
1980	16	1258	286	10	2784	536
81	21	1615	456	17	4147	842
82	45	4111	778	17	4756	858
83	40	3775	903	15	3822	604
84	44	3891	1130	7	1889	385
85	23	2076	597	18	7644	1062
86	27	2145	644	19	5745	888
87	23	1865	525	33	9477	1288
88	37	3229	797	43	11709	1984
89	19	1572	251	32	8716	1561
1990	28	1989	287	40	9901	2012
91	23	1894	397	45	10873	1782
92	25	2048	445	48	10878	1906

Table 4. Summary of commercial samples used to estimate catch at age in 1992.

GEAR	MONTH	WEIGHT (t)	LENGTHS	AGES	WEIGHT	GEAR TOTAL
a. Canadian catch						
OTB +MISC	JAN	270				
	FEB	388				
	MAR	19				
	APR	22				
	MAY	36	2470	780	3711	
	JUN	2976				
	JUL	1047				
	AUG	334	3049	845	1614	6021
	SEP	233				
	OCT	546				
	NOV	140	1011	281	696	
	DEC	10				
LL	JAN	114				
	FEB	340	307	48	929	
	MAR	475				
	APR	275				
	MAY	237	1133	732	1310	4474
	JUN	799				
	JUL	676				
	AUG	612	1049	845	1797	
	SEP	509				
	OCT	337				
	NOV	101	346	281	438	
	DEC	0				
GN	MAY	1				
	JUN	294	459	780	294	
	JUL	350				
	AUG	342				
	SEP	203	1058	1126	922	1217
	OCT	26				
	NOV	2				
Grand Total						11712
b. USA catch						
	JAN	755				
	FEB	660	778	178	1954	
	MAR	539				
	APR	825				
	MAY	795	831	205	2174	
	JUN	554				
	JUL	97				
	AUG	57	92	20	189	
	SEP	35				
	OCT	37				
	NOV	261	347	42	763	
	DEC	465				
Grand Total						5080

Table 5. Catch at age of cod in numbers (000's) for Canada, USA and total, in 5Zjm ,1978-1992.

		AGEGROUP								
		1	2	3	4	5	6	7	8	9+	TOTAL
78	CDN	2	62	2017	667	205	78	57	12	12	3112
	USA	0	59	1571	409	102	32	26	9	0	2208
	TOT	2	121	3588	1076	307	110	83	21	12	5320
79	CDN	0	371	328	763	302	55	18	9	4	1850
	USA	10	443	71	1011	243	94	4	36	0	1912
	TOT	10	814	399	1774	545	149	22	45	4	3762
80	CDN	1	775	1121	214	420	125	32	11	14	2713
	USA	0	212	374	51	496	220	77	9	19	1458
	TOT	1	987	1495	265	916	345	109	20	33	4171
81	CDN	2	145	608	504	134	380	87	51	21	1932
	USA	17	458	835	745	21	215	82	14	15	2402
	TOT	19	603	1443	1249	155	595	169	65	36	4334
82	CDN	6	1283	1358	1105	742	164	221	97	21	4997
	USA	0	1399	328	324	324	25	124	60	16	2600
	TOT	6	2682	1686	1429	1066	189	345	157	37	7597
83	CDN	27	744	2506	1212	201	54	10	17	12	4783
	USA	13	575	910	262	265	229	21	54	27	2356
	TOT	40	1319	3416	1474	466	283	31	71	39	7139
84	CDN	0	26	118	375	340	123	72	19	18	1091
	USA	10	243	793	971	171	167	158	12	53	2578
	TOT	10	269	911	1346	511	290	230	31	71	3669
85	CDN	4	2146	904	383	497	139	45	38	9	4165
	USA	8	646	317	248	444	85	51	62	5	1866
	TOT	12	2792	1221	631	941	224	96	100	14	6031
86	CDN	19	235	1283	365	143	215	29	19	9	2317
	USA	9	91	905	148	161	185	29	20	16	1564
	TOT	28	326	2188	513	304	400	58	39	25	3881
87	CDN	14	2595	602	741	91	79	117	22	15	4276
	USA	0	1071	263	358	53	42	50	15	9	1861
	TOT	14	3666	865	1099	144	121	167	37	24	6137
88	CDN	10	232	2360	324	421	69	61	111	29	3617
	USA	0	88	1293	322	440	75	41	32	10	2301
	TOT	10	320	3653	646	861	144	102	143	39	5918
89	CDN	0	318	284	918	124	179	31	23	37	1914
	USA	0	422	368	919	69	135	25	2	4	1944
	TOT	0	740	652	1837	193	314	56	25	41	3858
90	CDN	7	339	1769	617	799	95	102	8	14	3750
	USA	0	339	1427	345	396	21	20	2	0	2550
	TOT	7	678	3196	962	1195	116	122	10	14	6300
91	CDN	11	493	512	1241	585	516	74	47	15	3483
	USA	0	137	261	669	350	263	20	10	3	1713
	TOT	11	630	773	1910	935	779	94	57	18	5196
92	CDN	70	1790	902	292	546	187	176	25	21	4009
	USA	16	567	349	140	362	62	57	0	5	1558
	TOT	86	2358	1251	432	908	250	253	25	27	5567

Table 6. Percent catch at age for total 5Zj,m landings, 1978-92.

	Year														
Age	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
1	0.04	0.27	0.02	0.44	0.08	0.56	0.27	0.20	0.72	0.23	0.17	0.00	0.11	0.21	1.54
2	2.27	21.64	23.66	13.91	35.30	18.48	7.33	46.29	8.40	59.74	5.41	19.18	10.76	12.13	42.36
3	67.44	10.61	35.84	33.29	22.19	47.85	24.83	20.25	56.38	14.09	61.73	16.90	50.73	14.88	22.47
4	20.23	47.16	6.35	28.82	18.81	20.65	36.69	10.46	13.22	17.91	10.92	47.62	15.27	36.76	7.76
5	5.77	14.49	21.96	3.58	14.03	6.53	13.93	15.60	7.83	2.35	14.55	5.00	18.97	17.99	16.31
6	2.07	3.96	8.27	13.73	2.49	3.96	7.90	3.71	10.31	1.97	2.43	8.14	1.84	14.99	4.49
7	1.56	0.58	2.61	3.90	4.54	0.43	6.27	1.59	1.49	2.72	1.72	1.45	1.94	1.81	4.54
8	0.39	1.20	0.48	1.50	2.07	0.99	0.84	1.66	1.00	0.60	2.42	0.65	0.16	1.10	0.45
9	0.23	0.11	0.79	0.83	0.49	0.55	1.94	0.23	0.64	0.39	0.66	1.06	0.22	0.35	0.49

Table 7. Mean size at age of cod in 5Zj,m derived from Canadian samples, 1978-92.

(a) Length (cm)

	Age group									
Year	1	2	3	4	5	6	7	8	9	10+
1978	39.5	48.9	59.0	63.3	69.6	81.2	82.5	98.3	94.7	115.0
1979	-	49.3	51.9	69.4	74.9	82.2	94.2	103.2	103.4	115.0
1980	36.6	48.8	59.5	66.2	76.4	83.6	86.6	104.7	105.7	115.0
1981	41.8	49.1	59.1	60.1	78.0	86.1	94.8	96.6	97.5	115.0
1982	38.3	50.1	58.9	70.0	77.8	84.4	94.9	95.2	106.4	115.0
1983	42.9	50.4	57.9	65.8	73.0	82.9	90.9	99.0	105.1	115.0
1984	-	50.7	60.4	70.0	75.7	82.3	92.3	100.1	100.7	115.0
1985	39.0	49.8	55.7	68.7	75.3	83.8	91.1	96.3	99.0	115.0
1986	39.6	51.7	63.5	71.0	79.6	86.8	92.8	95.9	96.3	115.0
1987	38.5	52.1	61.0	73.6	82.3	88.4	96.1	101.2	106.3	115.0
1988	40.9	48.3	60.5	70.4	80.2	84.8	95.2	99.9	102.5	115.0
1989	37.0	48.6	59.1	71.9	79.0	85.1	87.7	100.3	103.1	115.0
1990	41.7	54.3	63.1	69.0	77.6	84.0	92.0	102.0	107.4	115.0
1991	45.1	53.7	62.6	67.2	73.3	78.8	86.2	96.1	90.6	115.0
1992	46.1	51.3	60.6	67.1	73.6	80.3	85.3	94.6	105.7	115.0
Mean	43.1	50.5	59.5	68.2	76.4	83.7	90.8	98.9	101.6	115.0

(b) Weight (kg)

1978	0.707	1.376	2.346	2.922	3.918	6.187	6.625	10.148	9.429	15.0
1979	-	1.371	1.601	3.725	4.630	6.222	9.365	11.638	11.699	15.0
1980	0.567	1.343	2.426	3.235	4.997	6.468	7.119	12.135	12.652	15.0
1981	0.839	1.362	2.345	3.516	5.216	6.905	9.204	9.747	10.465	15.0
1982	0.652	1.444	2.324	3.816	5.188	6.550	9.137	9.418	12.667	15.0
1983	0.904	1.457	2.203	3.180	4.357	6.203	8.042	10.368	12.222	15.0
1984	-	1.477	2.473	3.794	4.751	6.043	8.633	10.622	10.807	15.0
1985	0.686	1.406	1.964	3.625	4.768	6.440	8.181	9.718	10.499	15.0
1986	0.723	1.572	2.877	3.952	5.592	7.179	8.612	9.453	9.934	15.0
1987	0.661	1.612	2.584	4.456	6.125	7.540	9.510	11.031	12.629	15.0
1988	0.786	1.294	2.518	3.904	5.716	6.694	9.251	10.700	11.531	15.0
1989	0.585	1.310	2.356	4.153	5.471	6.820	7.459	10.757	11.680	15.0
1990	0.831	1.812	2.829	3.699	5.221	6.657	8.582	11.227	10.080	15.0
1991	1.051	1.756	2.783	3.470	4.432	5.591	7.116	9.604	8.457	15.0
1992	1.135	1.547	2.557	3.485	4.535	5.863	7.113	9.553	12.577	15.0
Mean	0.779	1.476	2.412	3.662	4.994	6.491	8.263	10.408	11.156	15.0

Table 8. Stratified mean catch per tow in numbers for USA and Canadian research surveys in 5Zj,m, 1978-93. Adjusted for vessel and door conversions.

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
USA spring a,b																	
1		0.27	0.69	0.03	1.70	0.79	0.69	0.20	0.08	1.13	0.01	0.58	0.21	0.13	1.31	0.14	
2		0.01	2.65	2.96	1.57	11.58	3.63	0.22	3.67	0.62	2.17	0.45	1.55	0.62	1.12	1.20	
3		5.10	0.22	2.90	2.43	24.99	6.33	0.81	1.15	2.05	0.46	5.05	0.47	3.14	0.92	0.65	
4		1.12	2.57	0.28	1.73	22.29	1.36	1.22	1.92	0.55	0.98	0.50	2.39	1.09	1.63	0.17	
5		1.61	1.00	3.01	0.07	16.98	1.06	0.48	2.75	0.78	0.01	0.84	0.46	1.18	0.83	0.45	
6		0.34	0.34	0.59	0.60	0.01	0.66	0.39	0.60	0.98	0.34	0.08	0.54	0.29	0.69	0.27	
7		1.37	0.17	0.12	0.31	5.55	0.28	0.34	0.35	0.05	0.28	0.03	0.07	0.30	0.08	0.29	
8		0.19	0.22	0.08	0.12	1.24	0.11	0.01	0.45	0.21	0.06	0.14	0.06	0.03	0.03	0.05	
9		0.08	0.01	0.06	0.01	0.70	0.01	0.22	0.13	0.27	0.11	0.01	0.09	0.01	0.02	0.09	
USA autumn a,b																	
0	0.10	0.21	0.32	0.60	0.60	0.01	1.47	0.06	2.24	0.22	0.29	0.18	0.41	0.36	0.01	0.00	
1	0.01	2.64	2.96	1.43	4.24	1.05	0.12	2.84	0.39	5.20	0.24	1.02	0.72	0.72	0.36	0.37	
2	6.31	0.26	2.93	0.76	2.19	1.29	0.42	0.14	1.80	0.11	1.53	0.33	1.68	0.79	0.13	1.31	
3	1.26	5.10	0.21	1.21	1.69	0.08	0.89	1.03	0.30	0.35	0.23	2.13	0.28	1.49	0.16	0.28	
4	0.35	0.73	2.71	0.05	0.48	0.12	0.05	1.68	0.03	0.01	0.19	0.25	0.77	0.21	0.02	0.00	
5	0.27	0.11	0.44	0.35	0.02	0.01	0.03	0.05	0.01	0.01	0.01	0.44	0.10	0.37	0.06	0.07	
6	0.33	0.11	0.16	0.04	0.05	0.01	0.03	0.06	0.03	0.02	0.01	0.01	0.04	0.04	0.01	0.02	
7	0.04	0.16	0.05	0.05	0.01	0.06	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.01	0.01	0.00	
8	0.01	0.01	0.04	0.05	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.09	0.01	0.02	0.01	0.00	
Canadian spring																	
1										1.81	0.12	0.36	0.84	0.26	2.75	0.12	0.07
2										8.33	4.31	1.08	5.01	1.81	2.31	4.69	0.82
3										7.50	1.55	12.85	1.77	7.97	3.23	2.81	3.96
4										0.76	1.81	1.36	3.90	4.49	3.74	0.94	1.43
5										1.61	0.39	2.02	0.58	10.11	1.99	1.48	0.85
6										1.04	0.21	0.23	0.76	1.23	2.70	1.04	1.73
7										0.52	0.44	0.19	0.09	2.51	0.33	0.69	0.63
8										0.08	0.21	0.43	0.19	0.33	0.56	0.21	0.61
9										0.15	0.03	0.04	0.25	0.36	0.08	0.09	0.12

a. Door conversion coefficient of 1.56 used on 1977-84 spring and fall surveys
b. Vessel conversion coefficient of 0.79 used on 1981-82 and 1989-91 spring surveys and on 1977-81 and 1989-91 fall surveys. No conversion for 1992 USA surveys (Albatross)

Table 9 . Georges Bank cod revised population estimates from ADAPT

Age	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
								Year								
a) Numbers (000's)																
1	11190	9545	9270	17295	6352	4658	13600	4732	22246	6996	13357	3958	4531	10912	2004	1
2	2236	9160	7805	7589	14142	5195	3777	11126	3863	18188	5715	10927	3240	3703	8924	1563
3	10666	1721	6763	5497	5667	9152	3060	2849	6583	2868	11574	4389	8277	2039	2465	5173
4	3539	5486	1048	4184	3195	3115	4402	1681	1228	3410	1565	6171	3004	3885	961	887
5	1023	1924	2886	618	2296	1323	1216	2386	805	541	1797	697	3390	1589	1426	396
6	377	559	1082	1534	366	915	662	533	1102	384	313	692	396	1694	439	346
7	305	209	323	574	718	129	493	279	234	540	205	126	283	219	672	133
8	41	175	151	166	317	275	77	195	142	139	291	76	52	121	95	340
9	41	15	102	106	77	117	161	35	70	81	80	109	39	34	48	56
3+	15991	10089	12356	12679	12636	15026	10071	7960	10164	7963	15826	12260	15441	9581	6107	7329
b) Biomass (t)																
1	7911	7149	5256	14510	4142	4211	10186	3246	16084	4624	10499	2316	3765	11469	2275	1
2	3076	12558	10483	10336	20422	7570	5579	15643	6073	29319	7395	14314	5871	6503	13806	2307
3	25022	2755	16406	12892	13171	20162	7568	5596	18938	7411	29143	10341	23415	5675	6304	12479
4	10340	20434	3390	14711	12193	9904	16702	6094	4853	15193	6111	25626	11111	13479	3349	3247
5	4006	8907	14422	3224	11909	5765	5778	11378	4504	3315	10272	3814	17699	7042	6467	1978
6	2332	3481	6998	10593	2396	5675	3998	3435	7913	2898	2094	4721	2637	9472	2571	2245
7	2023	1958	2301	5279	6557	1033	4256	2285	2015	5140	1898	938	2426	1561	4781	1098
8	421	2035	1836	1618	2983	2855	820	1900	1340	1535	3118	814	588	1162	912	3534
9	383	175	1296	1107	976	1433	1743	369	691	1020	927	1275	397	286	609	619
3+	44527	39745	46649	49425	50186	46827	40863	31056	40254	36511	53564	47531	58271	38677	24993	25199
c) Fishing Mortality																
1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	
2	0.06	0.10	0.15	0.09	0.24	0.33	0.08	0.32	0.10	0.25	0.06	0.08	0.26	0.21	0.35	
3	0.46	0.30	0.28	0.34	0.40	0.53	0.40	0.64	0.46	0.41	0.43	0.18	0.56	0.55	0.82	
4	0.41	0.44	0.33	0.40	0.68	0.74	0.41	0.54	0.62	0.44	0.61	0.40	0.44	0.80	0.69	
5	0.40	0.38	0.43	0.32	0.72	0.49	0.62	0.57	0.54	0.35	0.75	0.37	0.49	1.09	1.22	
6	0.39	0.35	0.43	0.56	0.85	0.42	0.66	0.62	0.51	0.43	0.71	0.70	0.39	0.72	0.99	
7	0.36	0.12	0.47	0.39	0.76	0.31	0.72	0.48	0.32	0.42	0.80	0.68	0.65	0.63	0.48	
8	0.82	0.33	0.16	0.57	0.79	0.34	0.59	0.83	0.36	0.35	0.78	0.45	0.24	0.72	0.34	
9	0.40	0.35	0.44	0.47	0.76	0.46	0.67	0.58	0.51	0.40	0.77	0.54	0.50	0.89	0.96	
3+	0.45	0.39	0.34	0.39	0.57	0.56	0.47	0.60	0.49	0.42	0.50	0.34	0.52	0.78	0.86	

Table 10. Population abundance estimates from ADAPT

1993 Popn Age		SE	RE	Bias	Rel Bias
2	1.563E3	8.215E2	5.254E-1	2.291E2	1.466E-1
3	5.173E3	2.370E3	4.581E-1	5.117E2	9.892E-2
4	8.867E2	4.857E2	5.478E-1	1.132E2	1.277E-1
5	3.960E2	2.613E2	6.599E-1	6.386E1	1.612E-1
6	3.463E2	2.220E2	6.409E-1	6.424E1	1.855E-1
7	1.329E2	8.377E1	6.303E-1	2.371E1	1.784E-1
8	3.396E2	2.287E2	6.732E-1	5.465E1	1.609E-1
9	5.552E1	3.412E1	6.145E-1	8.157E0	1.469E-1
USA spr RV					
1	4.294E-5	1.135E-5	2.643E-1	1.141E-6	2.656E-2
2	2.137E-4	5.589E-5	2.615E-1	5.580E-6	2.611E-2
3	3.742E-4	9.422E-5	2.518E-1	9.230E-6	2.467E-2
4	7.362E-4	8.170E-5	1.110E-1	-1.155E-6	-1.569E-3
USA fall RV					
0	3.751E-5	1.018E-5	2.715E-1	1.060E-6	2.826E-2
1	1.509E-4	3.853E-5	2.553E-1	3.694E-6	2.448E-2
2	1.620E-4	3.980E-5	2.456E-1	3.880E-6	2.395E-2
3	2.191E-4	2.733E-5	1.247E-1	4.498E-7	2.053E-3
CDN spring RV					
1	1.624E-4	5.752E-5	3.542E-1	7.851E-6	4.835E-2
2	5.053E-4	1.793E-4	3.549E-1	2.443E-5	4.834E-2
3	8.822E-4	3.099E-4	3.514E-1	4.393E-5	4.980E-2
4	1.496E-3	2.444E-4	1.633E-1	6.893E-6	4.607E-3

Table 11. Residuals for survey indices from ADAPT

Age	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
a) USA spring																	
1		-0.59	0.52	-2.55	0.83	1.06	1.23	-1.06	-0.93	0.17	-3.40	0.01	0.23	-0.43	1.03	0.49	
2		-3.42	0.30	0.57	-0.04	1.34	1.19	-1.31	0.43	-0.29	-0.58	-1.00	-0.41	-0.10	0.35	-0.46	
3		0.25	-1.08	0.14	0.17	2.47	0.61	-0.34	0.08	-0.18	-0.85	0.15	-1.26	0.02	0.19	-0.35	
4		-0.84	-0.45	-1.01	-0.58	2.25	-0.52	-0.98	0.44	-0.50	-0.94	-0.84	-0.64	-0.71	-0.56	-1.43	
5		0.76	-0.35	0.35	-1.82	2.31	0.09	-0.62	0.45	0.27	-3.69	-0.45	-0.11	-0.75	-0.34	-0.85	
6		0.21	-0.18	-0.30	-0.63	-3.08	-0.03	-0.22	0.42	0.19	0.18	-1.06	0.05	0.00	-0.60	-0.18	
7		1.81	0.11	-0.65	-0.32	2.35	1.09	-0.06	0.53	-1.24	-0.35	-1.62	-0.26	0.37	-0.71	-0.53	
8		1.81	0.53	-0.36	0.01	1.67	-0.62	-1.29	1.14	0.70	-0.53	-0.43	-0.01	-0.20	-1.04	-0.34	
9		0.96	0.35	-0.19	-1.84	2.52	-1.71	0.61	1.61	1.66	0.61	-1.78	0.08	-1.30	-1.15	0.93	
b) USA fall																	
0	-1.45	-0.54	-0.08	-0.07	0.93	-2.42	1.06	-1.05	0.99	-0.18	-0.55	0.19	0.88	-0.14	-2.25	5.59	
1	-3.31	0.65	0.92	0.22	0.69	0.29	-1.52	0.53	-0.40	0.64	-1.28	-0.48	0.39	0.25	-1.33	0.45	
2	1.30	-0.07	0.98	-0.15	0.87	-0.14	-0.16	-1.19	0.52	-1.44	-0.20	-0.77	0.23	0.87	-1.09	0.45	
3	0.48	1.45	-0.09	0.28	0.88	-2.17	-0.08	1.03	0.11	-0.76	-0.40	0.45	-0.84	0.56	-0.29	0.37	
4	0.43	0.55	1.46	-1.01	-0.05	-0.84	-1.74	1.17	-1.77	-2.47	-0.73	0.49	0.03	-0.49	-2.58	-2.16	
5	1.19	-0.10	0.63	0.03	-1.18	-2.55	-1.54	-0.92	-3.18	-2.13	-1.92	1.06	0.17	0.00	-0.55	-0.08	
6	1.60	0.88	0.82	-1.22	-1.16	-0.59	-1.24	0.02	-0.54	-1.78	-1.50	-1.01	-0.45	-0.20	-2.93	-0.38	
7	1.40	1.43	0.40	0.30	-1.73	0.03	-0.08	-1.01	-1.13	-1.11	-1.85	1.44	-0.37	-1.21	-0.97	-2.01	
8	0.33	1.33	0.50	0.75	-0.31	-0.50	0.28	0.71	-0.42	-0.57	-0.57	1.32	-0.09	1.16	-0.29	-0.20	
c) Canadian spring																	
1										-0.69	-2.25	-1.80	0.27	-1.04	0.44	-1.00	6.07
2										1.45	-0.76	-0.98	-0.10	0.10	0.21	0.04	0.04
3										0.26	-0.49	0.23	-0.78	0.09	0.59	0.26	-0.14
4										-0.88	-1.04	-0.54	-0.86	0.00	-0.44	-0.43	0.07
5										0.29	-0.73	-0.29	-0.59	0.69	-0.18	-0.37	0.36
6										-0.46	-1.01	-0.71	-0.31	0.73	0.06	0.46	1.21
7										0.40	-0.61	-0.48	-0.74	1.78	0.01	-0.38	1.15
8										-0.98	0.01	-0.01	0.52	1.44	1.13	0.39	0.18
9										0.37	-1.39	-1.10	0.43	1.81	0.46	0.22	0.37

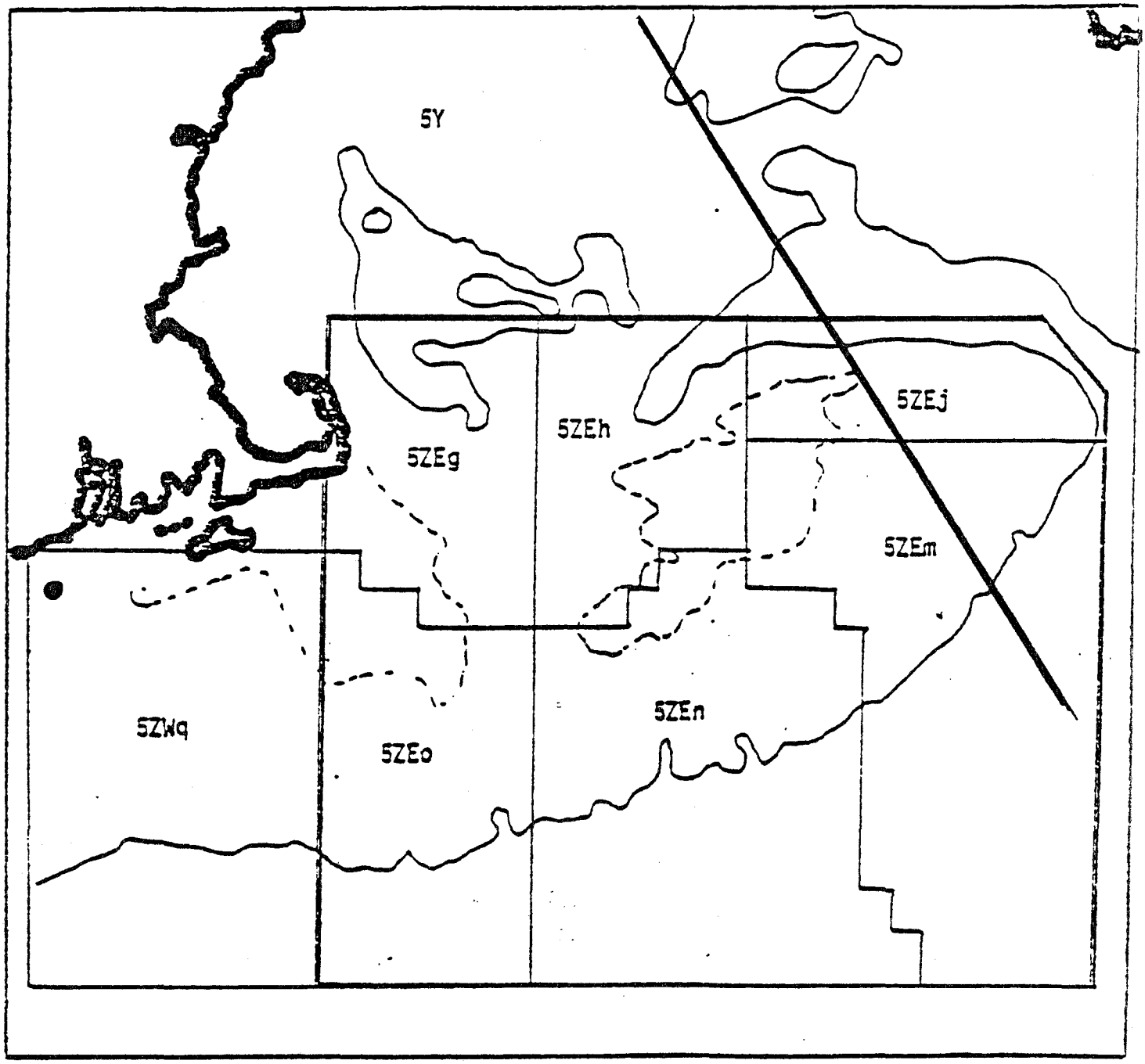

Figure 1. NAFO statistical areas for Georges Bank

Figure 2. Canadian landings by gear type of Georges Bank cod

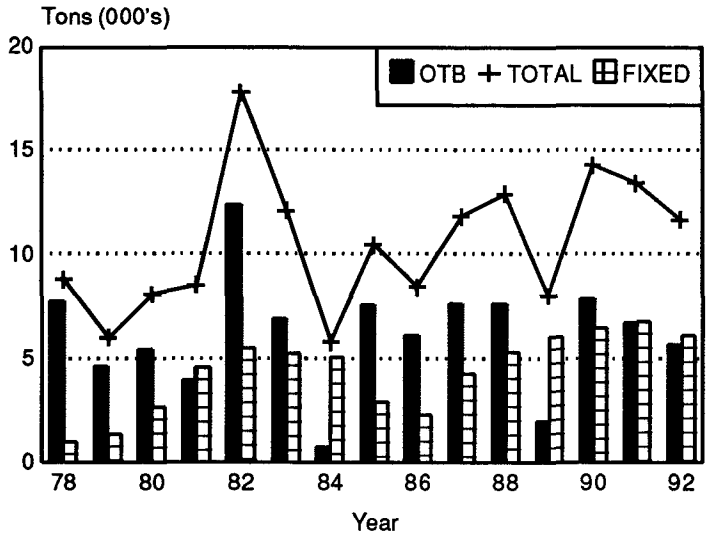

Figure 3. Canadian and USA landings of 5Zj,m cod.

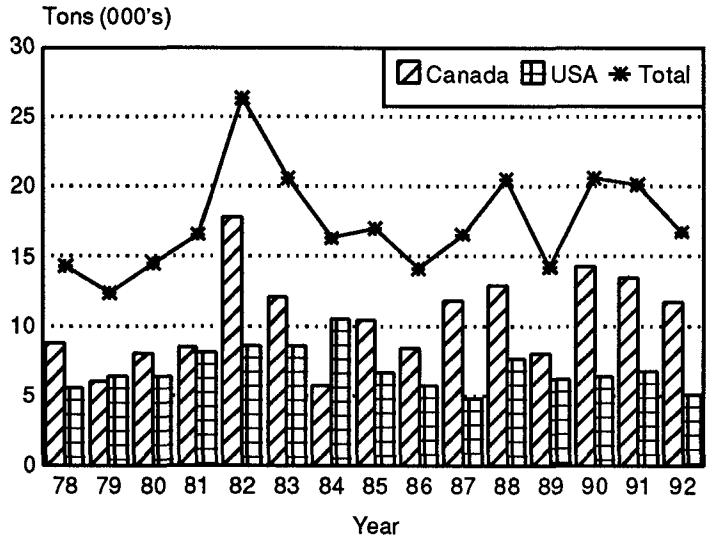

Figure 4. Average proportion by month for 5Zj,m cod landings, 1985-92

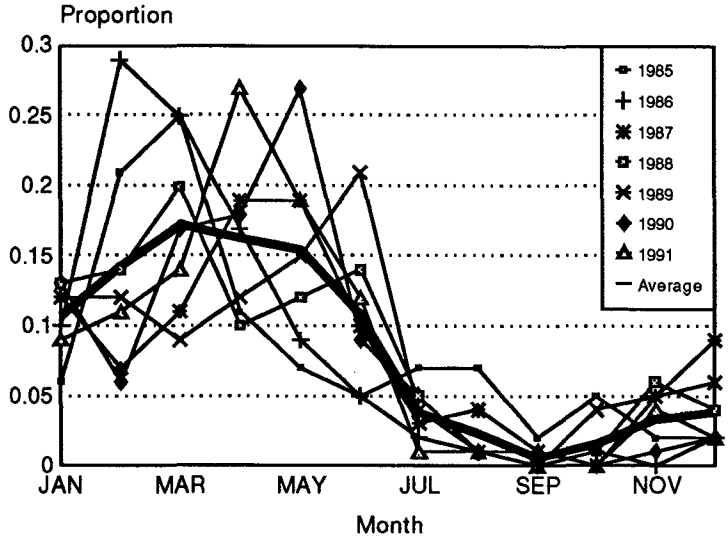

Figure 5. Average proportion by month for 5Zj,m cod landings, 1985-92

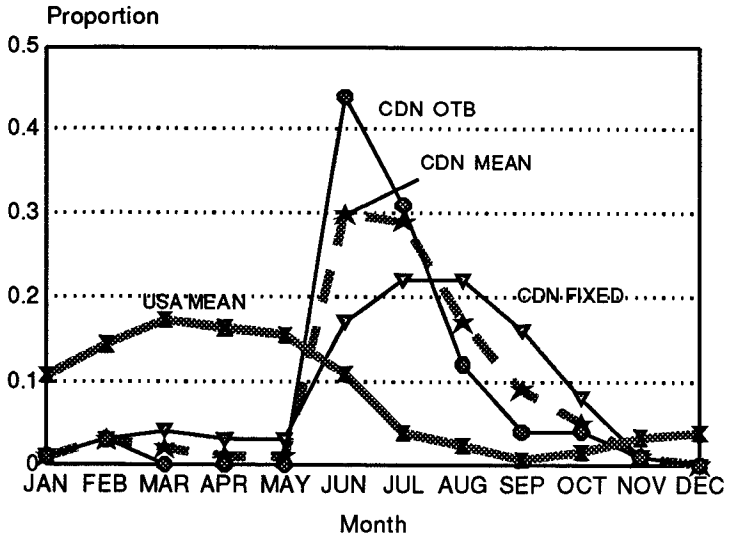

Figure 6. Standardized (to maximim) catch per tow for ages 1-9 in research surveys, 1978-93. (US spring '82 excluded)

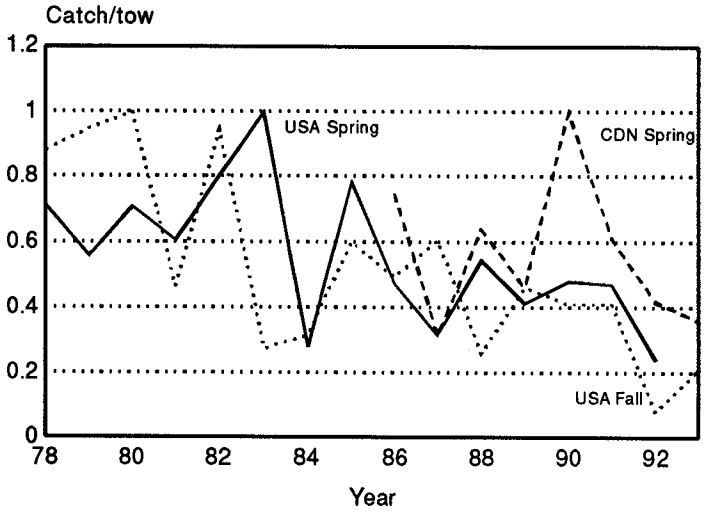

Figure 7a. Population (3+) numbers for 5Zj,m cod

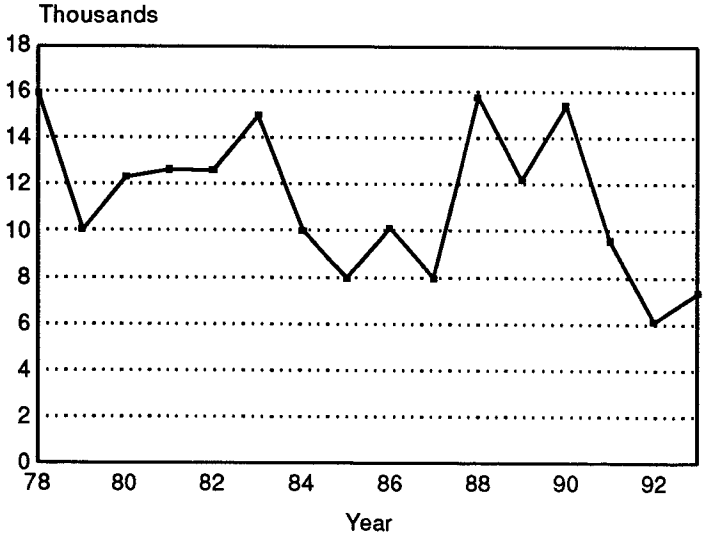

Figure 7b. Population (3+) biomass for 5Zj,m cod

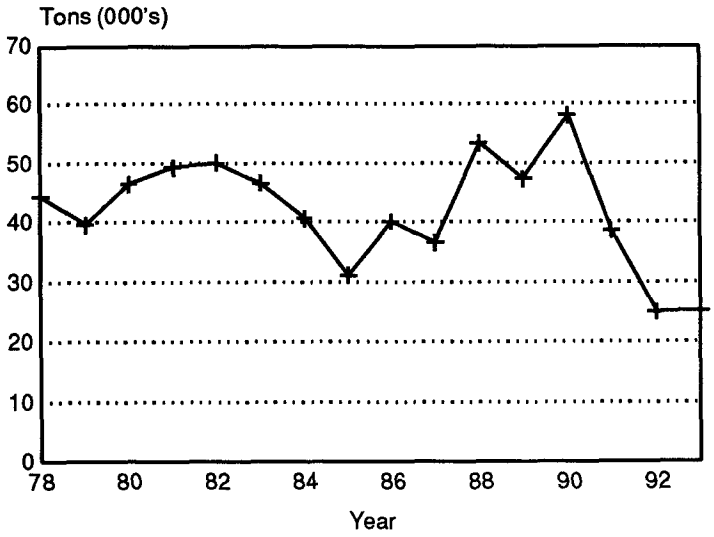

Figure 7c. Population (3+) fishing mortality for 5Zj,m cod

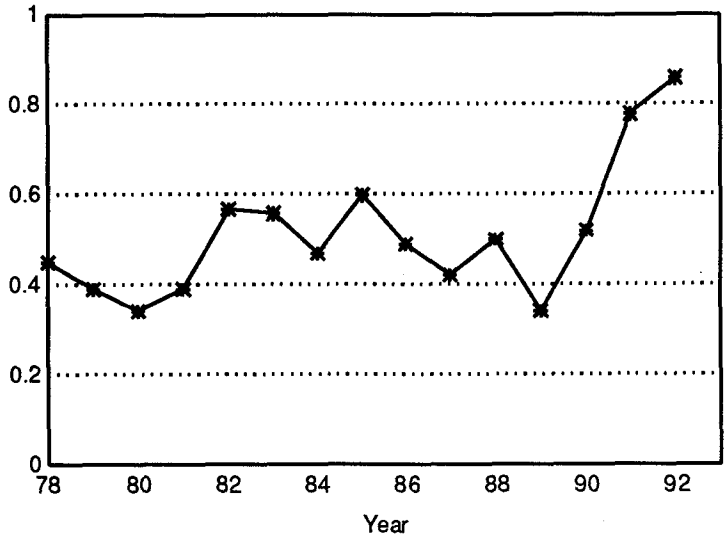

Figure 8. OTB length frequencies for Canadian landings by quarter