Northeast Fisheries Science Center Reference Document 93-05

Assessment of the Georges Bank Cod Stock for 1992

by

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This document was presented to and reviewed by the Stock Assessment Review Committee (SARC) of the 15th Northeast Regional Stock Assessment Workshop (15th SAW)

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Seven documents associated with the The 15th Regional Stock Assessment Workshop (15th SAW) have been published as Northeast Fisheries Science Center reference documents. For copies of these documents, contact the NMFS/NEFSC, Information Services Unit, 166 Water Street, Woods Hole, MA 02543-1097, (508)548-5123.

Reports associated with the 15th Regional Stock Assessment Workshop (15th SAW)

CRD 93-01 Surfclam populations of the Middle Atlantic, Southern New England, and Georges Bank for 1992
by James R. Weinberg

CRD 93-02 Ocean quahog populations of the Middle Atlantic, Southern New England, and Georges Bank, and Gulf of Maine for 1992
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CRD 93-03 Historic and recent trends in the population dynamics of redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine - Georges Bank region
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CRD 93-04 Assessment of the Gulf of Maine cod stock for 1992
by Ralph K. Mayo, Loretta O'Brien, Fredric M. Serchuk

CRD 93-05 Assessment of the Georges Bank cod stock for 1992
by Fredric M. Serchuk, Ralph K. Mayo, Loretta O'Brien, and Susan E. Wigley

CRD 93-06 Report of the 15th Northeast Regional Stock Assessment Workshop (15th SAW), Stock Assessment Review Committee (SARC) Consensus Summary of Assessments

CRD 93-07 Report of the 15th Northeast Regional Stock Assessment Workshop (15th SAW), the Plenary

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INTRODUCTION

Atlantic cod (*Gadus morhua*) in the Georges Bank area have been commercially exploited since the 17th century. Reliable landings statistics are available since 1893. Historically, the Georges Bank fishery (NAFO Division 5Z and Subarea 6) can be separated into five periods (Serchuk and Wigley 1992) (Figure 1):

(1) 1893-1914, when high landings (greater than 40,000 mt) in 1895 and 1906-07 were followed by about 10 years of sharply reduced landings;
(2) 1915-1940, when annual landings fluctuated between 20,000 and 30,000 mt, and when cod was generally taken as a bycatch in the Georges Bank haddock fishery;
(3) 1940-1960, when landings declined, reaching a record low of 8,100 mt in 1953. Declines in this period reflect a reduction in fishing activity during World War II and redirection of remaining fleet effort towards the more abundant haddock resource;
(4) 1960-1976, when Canadian and distant-water fleet fisheries for Georges Bank cod developed. Large increases in fishing effort for cod during this period resulted in a fivefold increase in annual landings between 1960 and 1966 (11,000 to 53,000 mt) but landings sharply declined afterward reaching only 20,000 mt in 1976;
(5) 1977 onward, after the implementation of extended fisheries jurisdiction by both the United States and Canada. Total landings of Georges Bank cod doubled between 1977 and 1982 (27,000 to 57,000 mt), declined to 26,000 mt in 1986, but increased to 42,500 mt in 1990 (Table 1).

Commercial landings declined in 1991 to 37,600 mt and are expected to be only about 28,100 mt in 1992. Since October 1984, when the International Court of Justice delimited a maritime boundary between the United States and Canada in the Gulf of Maine/Georges Bank region, fishing activity by each country has been restricted to its own waters on Georges Bank.

This report presents an updated and revised analytical assessment of the Georges Bank cod

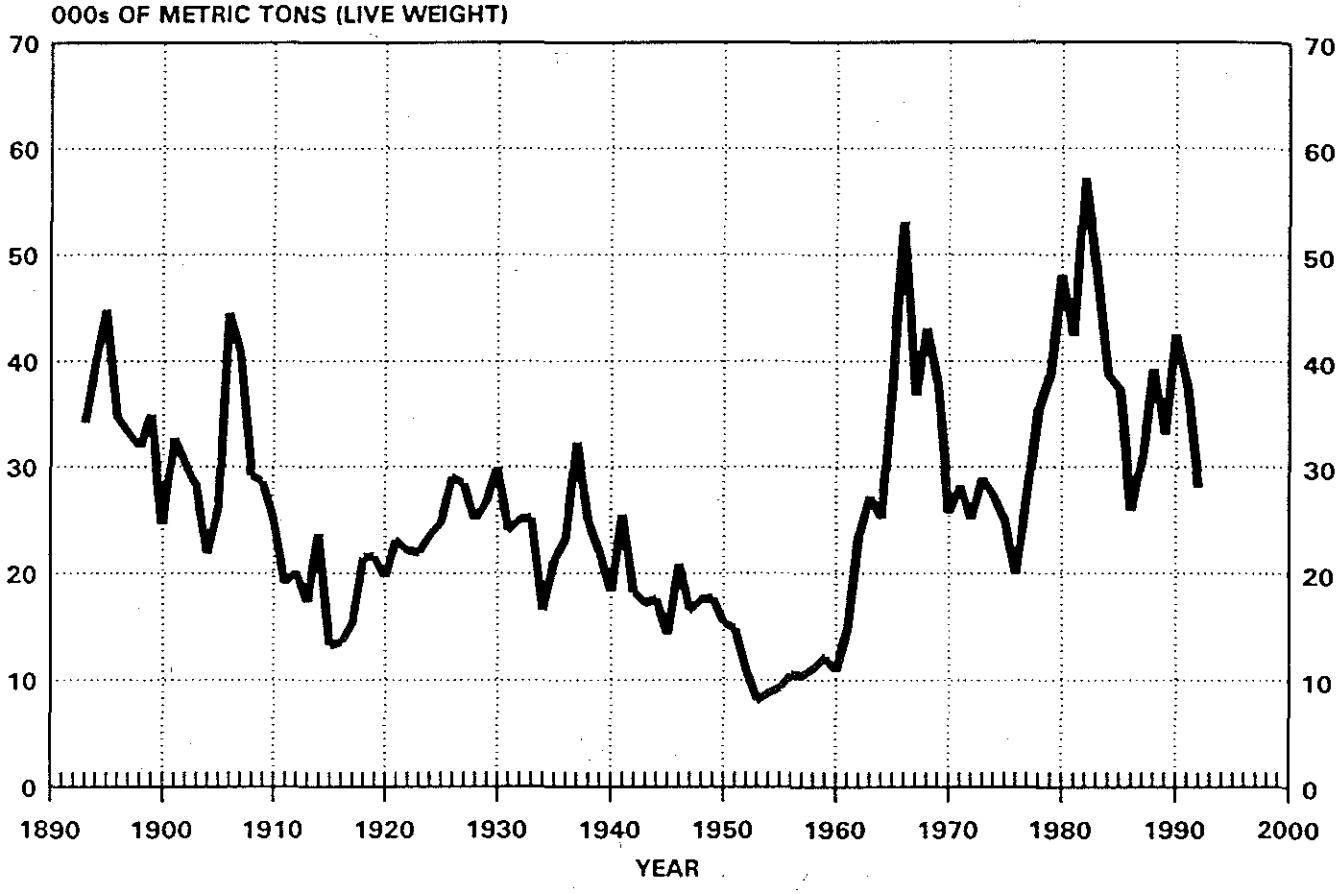

Figure 1. Total commercial landings of Georges Bank cod (Divisions 5Z and 6), 1893-1992.

Table 1. Commercial landings (metric tons, live) of Atlantic cod from Georges Bank and South (Division 5Z and Subarea 6), 1960-1992

	Country						
Year	USA	Canada	USSR	Spain	Poland	Other	Total
1960	10834	19	-	-	-	-	10853
1961	14453	223	55	-	-	-	14731
1962	15637	2404	5302	-	143	-	23486
1963	14139	7832	5217	-	-	1	27189
1964	12325	7108	5428	18	48	238	25165
1965	11410	10598	14415	59	1851	-	38333
1966	11990	15601	16830	8375	269	69	53134
1967	13157	8232	511	14730	-	122	36752
1968	15279	9127	1459	14622	2611	38	43136
1969	16782	5997	646	13597	798	119	37939
1970	14899	2583	364	6874	784	148	25652
1971	16178	2979	1270	7460	256	36	28179
1972	13406	2545	1878	6704	271	255	25059
1973	16202	3220	2977	5980	430	114	28923
1974	18377	1374	476	6370	566	168	27331
1975	16017	1847	2403	4044	481	216	25008
1976	14906	2328	933	1633	90	36	19926
1977	21138	6173	54	2	-	-	27367
1978	26579	8778	-	-	-	-	35357
1979	32645	5978	-	-	-	-	38623
1980	40053	8063	-	-	-	-	48116
1981	33849	8499	-	-	-	-	42348
1982	39333	17824	-	-	-	-	57157
1983	36756	12130	-	-	-	-	48886
1984	32915	5763	-	-	-	-	38678
1985	26828	10443	-	-	-	-	37271
1986	17490	8411	-	-	-	-	25901
1987	19035	11845	-	-	-	-	30880
1988	26310	12932	-	-	-	-	39242
1989	25097	8001	-	-	-	-	33098
1990	28193	14310	-	-	-	-	42503
1991[1]	24175	13455	-	-	-	-	37630
1992[2]	15700	12400	-	-	-	-	28100

[1]Provisional
[2]Predicted

stock (NAFO Division 5Z and Statistical Area 6) for the period 1978-1991 based on analysis of commercial landings and effort data and research vessel survey data through 1991. Previous analytical assessments of this stock were conducted by the United States in 1986 (Serchuk and Wigley 1986; NEFC 1986), in 1988 (Serchuk 1988; NEFC 1989), in 1990 (Serchuk and Wigley 1990; NEFC 1990), and in 1991 (Serchuk *et al.* 1991; NEFSC 1992). Analytical assessments of the component of the Georges Bank cod stock in Canadian waters (Unit Areas 5Zj and 5Zm) have been conducted by CAFSAC [Canadian Atlantic Fisheries Scientific Advisory Committee] in 1990 (Hunt 1990), 1991 (Hunt *et al.* 1991), and 1992 (Hunt and Buzeta 1992).

RECREATIONAL FISHERY CATCHES

Estimates of recreational cod landings by U.S. marine anglers are available from the national saltwater angling surveys conducted in 1960, 1965, and 1970, a 1974 northeastern coast regional marine recreational survey, and annual National Marine Fisheries Service (NMFS) Marine Recreational Fishery Statistics Surveys (MRFSS) conducted since 1979. The latter series of surveys are considered the most reliable relative to catch data since they employ a standardized statistical design involving a combination household telephone survey and an intercept (onsite creel census) survey to obtain landings data at the species level.

Table 2. Estimated number (000s) and weight (metric tons, live) of Atlantic cod caught by marine recreational fishermen in 1960, 1965, 1970, 1974, and 1979-1991[1]

Year	All Regions		Georges Bank Stock	
	Number of Cod (000s)	Weight of Cod (mt)	Number of Cod (000s)	Weight of Cod (mt)
1960	4791	14016	Not Estimated	
1965	5032	13565	Not Estimated	
1970	3844	16292	Not Estimated	
1974	2901	12368	Not Estimated	
1979	3091	4026	393	580
1980	2440	7331	186	471
1981	4845	9712	1605	4677
1982	3250	8244	1453	5296
1983	3747	7542	1693	4920
1984	2562	5080	832	2406
1985	3674	7664	1998	4635
1986	1548	3510	331	1092
1987	2063	3779	467	1168
1988	2966	7327	1494	4284
1989	2463	6119	538	1875
1990	2635	5144	690	1696
1991	1854	3727	444	1255

[1] **From 1979-1991 Marine Recreational Fishery Statistics Survey expanded catch estimates.**

Estimated recreational cod catches [from both the Georges Bank and Gulf of Maine cod stocks combined, and including fish reported caught and subsequently released alive] during 1960-1989 ranged between 3,500 mt (1986) and 16,300 mt (1970) (Table 2). The highest estimates were derived prior to 1979, but must be considered tentative due to methodological weaknesses and differences in survey procedures in these years (United States Department of Commerce 1979: p. 21). Between 1981 and 1985, annual recreational cod landings exhibited little variability; apart from 1984, annual catches varied between 8,000 and 9,000 mt, and averaged 8,500 mt per year. Recreational cod catches declined in 1986 and 1987 to less than 4,000 mt, increased to more than 6,000 t in 1988 and 1989, but declined to 5,000 mt in 1990 and were only 3,700 mt in 1991.

Preliminary estimates of recreational catches of cod by stock unit have recently been derived using landing site information (from intercept surveys) to allocate catches between the Gulf of Maine and Georges Bank stocks (Recreational Fisheries Statistics Working Group 1992). Between 1981 and 1985, estimated catches from the Georges Bank stock (Division 5Z and Subarea 6) ranged between 2,400 and 5,300 mt and averaged 4,400 mt per year (Table 2). Since 1986, however, recreational catches of Georges Bank cod have averaged just 1,900 mt per year, and accounted (apart from 1988) for only a third of the total U.S. recreational cod landings. Of the total annual Georges Bank cod catches (commercial and recreational), recreational landings have accounted for between 3 and 10% of the overall yearly totals.

Recreational catches have not been included in any of the assessment analyses since a number of problems still remain in estimating the quantity and size/age composition of the recreational catch, by stock (Recreational Fisheries Statistics Working Group 1992). Among these are:

(1) lack of recreational catch estimates in January and February when some party boats in Massachusetts, Rhode Island, and New York land cod;
(2) inability to properly categorize catches of long-range trips (*e.g.*, to Georges Bank) that are being made in increasing numbers by party boats, from Maine to New York;
(3) catch estimates for the Georges Bank stock are imprecise [*i.e.*, relatively large CVs], and
(4) length frequency sampling intensity, particularly for the Georges Bank stock, is low and is probably insufficient to accurately characterize the size composition of the catch. Moreover, length frequency sampling is opportunistic and thus samples are not distributed in proportion to the catch, by time, fishing mode, or state of landing.

COMMERCIAL FISHERY LANDINGS

Total commercial landings in 1991 were 37,600 mt, 11% lower than in 1990 (Table 1). The United States and Canada, sole participants in the fishery since 1978, accounted for 64 and 36%, respectively, of the 1991 total. The 1991 U.S. landings (24,200 mt) were 14% less than in 1990, and the fourth lowest U.S. total since 1977. Canadian 1991 landings totaled 13,500 mt, 6% lower than in 1990, but still the fourth highest Canadian landings ever.

As in the past, otter trawl landings accounted for most (68%) of the 1991 landings. The otter trawl fishery accounted for 80% of the 1991 U.S.

Table 3. Distribution of U.S. commercial landings (metric tons, live) of Atlantic cod from Georges Bank (Area 5Ze) by gear type, 1965-1992. The percentage of total U.S. commercial landings of Atlantic cod from Georges Bank by gear type is also presented for each year. Data only reflect Georges Bank cod landings that could be identified by gear type.

	Landings (mt, live)						Percentage of Annual Landings					
Year	Otter Trawl	Sink Gill Net	Line Trawl	Handline	Other Gear	Total	Otter Trawl	Sink Gill Net	Line Trawl	Handline	Other Gear	Total
1965	10251	0	582	505	9	11347	90.3	-	5.1	4.5	0.1	100.0
1966	10206	0	787	757	19	11769	86.7	-	6.7	6.4	0.2	100.0
1967	10915	0	894	704	9	12522	87.2	-	7.1	5.6	0.1	100.0
1968	12084	0	936	524	<1	13544	89.2	-	6.9	3.9	-	100.0
1969	13194	0	1371	387	<1	14952	88.2	-	9.2	2.6	-	100.0
1970	11270	0	1676	404	<1	13350	84.4	-	12.6	3.0	-	100.0
1971	12436	0	2334	230	2	15002	82.9	-	15.6	1.5	-	100.0
1972	10179	0	2071	217	10	12477	81.6	-	16.6	1.7	0.1	100.0
1973	12431	3	2185	206	21	14846	83.7	-	14.7	1.4	0.2	100.0
1974	14078	3	2548	11	9	16649	84.6	-	15.3	0.1	-	100.0
1975	12069	0	2435	84	4	14592	82.7	-	16.7	0.6	-	100.0
1976	12257	4	1519	153	5	13938	88.0	-	10.9	1.1	-	100.0
1977	18529	30	912	83	22	19576	94.7	0.2	4.7	0.4	0.1	100.0
1978	20862	81	1569	1180	59	23751	87.8	0.3	6.6	5.0	0.3	100.0
1979	26562	620	2707	860	159	30908	85.9	2.0	8.8	2.8	0.5	100.0
1980	32479	4491	1102	0	273	38345	84.7	11.7	2.9	-	0.7	100.0
1981	27694	3515	120	584	197	32110	86.2	10.9	0.4	1.8	0.6	100.0
1982	33371	2935	385	624	210	37525	88.9	7.8	1.0	1.7	0.6	100.0
1983	30981	1812	831	441	81	34146	90.7	5.3	2.4	1.3	0.3	100.0
1984	26161	2573	366	753	197	30050	87.1	8.6	1.2	2.5	0.6	100.0
1985	21444	2482	436	284	163	24809	86.4	10.0	1.8	1.1	0.7	100.0
1986	13576	1679	692	305	95	16347	83.0	10.3	4.2	1.9	0.6	100.0
1987	13711	1522	1636	222	71	17162	79.9	8.9	9.5	1.3	0.4	100.0
1988	20296	1864	1950	232	116	24458	83.0	7.6	8.0	0.9	0.5	100.0
1989	17946	3150	1583	119	91	22889	78.4	13.8	6.9	0.5	0.4	100.0
1990	21707[1]	2316	1252	395	133	25803	84.1	9.0	4.9	1.5	0.5	100.0
1991	17892[2]	2171	1919	286	180	22448	79.7	9.7	8.5	1.3	0.8	100.0
1992*						15700						

* Predicted

[1] Includes 849 mt taken by pair-trawl (Note: 1990 was the first year that pair-trawl landings exceeded a few metric tons)

[2] Includes 1068 mt taken by pair-trawl

landings (Table 3) and 50% of the Canadian landings (Hunt and Buzeta 1992). During 1978-1991, 85% of the U.S. landings and 61% of the Canadian landings were attributable to otter trawl gear.

SAMPLING INTENSITY

A summary of U.S. and Canadian length frequency and age sampling of Georges Bank cod landings during 1978-1991 is presented in Table 4. United States length frequency sampling averaged one sample per 320 mt landed over the 14-year period but, since 1982, has improved to one sample per 280m t landed. Sampling intensity in 1991 (1 sample per 275 mt) was greater than in preceding years (1989: 1 sample per 380 mt; 1990: 1 sample per 340 mt). Virtually all of the U.S. samples have been taken from otter trawl landings, but sampling is proportionally stratified by market category (scrod, market, and large). Of the 88 U.S. length frequency samples collected in 1991, 29 were scrod samples (33%), 41 were market samples (47%), and 18 were large (20%). This distribution was nearly identical to the 1991 U.S. landings distribution in terms of the total number of cod landed by market category (scrod: 37%; market: 49%; large: 14%). Comparison of length frequency samples taken from otter trawl landings with those obtained from fixed gears (a few samples from longlines and gill nets) revealed no obvious differences in size composition of fish, within a market category, by gear. Canadian sampling intensity has historically been much lower than that in the U.S. fishery. Prior to 1985, Canadian sampling coverage averaged about one sample per 1000 mt

Table 4. United States and Canadian sampling of commercial Atlantic cod landings from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978-1991

Year	United States				Canada			
	Length Samples		Age Samples		Length Samples		Age Samples	
	No.	# Fish Measured	No.	# Fish Aged	No.	# Fish Measured	No.	# Fish Aged
1978	88	6841	76	1463	29	7684	29	1308
1979	80	6973	79	1647	13	3991	13	656
1980	69	4990	67	1119	10	2784	10	536
1981	59	4304	59	1231	17	4147	16	842
1982	151	11970	147	2579	17	4756	8	858
1983	146	12544	138	2945	15	3822	14	604
1984	100	8721	100	2431	7	1889	7	385
1985	100	8366	100	2321	18	7644	18	1062
1986	94	7515	94	2222	19	5745	19	888
1987	80	6395	79	1704	33	9477	33	1288
1988	76	6483	76	1576	43	11709	43	1984
1989	66	5547	66	1350	32	8716	32	1561
1990	83	7158	83	1700	40	9901	40	2012
1991	88	7708	88	1865	45	10873	45	1782

Source: United States data: 1978-1988 from Serchuk and Wigley 1990 (SAW 11, Working Paper 1); United States data, 1989-1991, from NEFC files; Canadian data, 1978-1991, from Hunt and Buzeta 1992 (CAFSAC Res Doc 92/48).

landed (Hunt and Buzeta 1992). Sampling intensity has markedly improved since 1985 and has averaged one sample per 325 t landed during the 1986-1991 period. Sampling intensity in 1991 was 1 sample per 299 mt. Canadian samples are primarily from otter trawl landings (Hunt 1988, 1990). Canadian sampling is not done by market category but representative samples of the landings are taken.

AGE COMPOSITION

Age composition of U.S. landings during 1978-1991 was estimated, by market category, from monthly length frequency and age samples, pooled by calendar quarter. Quarterly mean weights, by market category, were obtained from applying the U.S. cod length-weight equation

$$(\ln \text{Weight}_{(kg,live)} = -11.7231 + 3.0521 \ln \text{Length}_{(cm)})$$

to the quarterly market category sample length frequencies. Mean weight values were then divided into quarterly market category landings to derive estimated numbers landed by quarter, by market category. Quarterly age/length keys were then applied to the quarterly market category numbers at length distributions to provide numbers at age. These values were summed over market categories and quarters to attain the annual U.S. landings-at-age matrix (Table 5). Derivation of catch by quarter, rather than by month, was performed since not all months had at least two length frequency samples per market category (*i.e.*, minimum desired for monthly catch estimates).

For many of the length frequency samples, sample weights were also available. These were converted (x 1.17) to live weights and compared to the calculated weights from the length-weight equation. In most cases, the differences were small (less than 5%) implying that use of the length-weight equation to derive landings numbers imparted little, if any, bias to the catch calculations.

Canadian landings-at-age data for 1978-1991 (Table 6) were taken from Hunt and Buzeta (1992) and combined with the U.S. data to produce an overall landings-at-age matrix for the 1978-1991 period (Table 7). The proportions of the total landings accounted for by the United States and Canada are also indicated in Table 7.

Commercial landings in 1991 were dominated by the 1987 and 1988 year classes (Table 8). Together, these two cohorts accounted for 60% of the landings by number and 52% by weight. The 1988 year class was much more

Table 5. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of U.S. commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978-1991

	Age										
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**
U.S. Commercial Landings in Numbers (000s) at Age											
1978	-	331	5731	1636	625	53	288	35	28	8	8735
1979	34	1618	572	4107	910	403	59	244	-	45	7992
1980	88	3002	4707	286	1888	951	413	76	153	-	11564
1981	25	3060	3613	1960	101	1026	330	72	109	46	10342
1982	325	7855	2466	1682	1258	117	452	116	50	57	14378
1983	81	3542	5557	1244	854	722	85	218	88	62	12453
1984	81	1281	3305	2961	500	393	386	25	153	82	9167
1985	130	4280	1539	985	1388	273	173	165	12	86	9031
1986	137	1091	3290	432	337	412	58	53	38	26	5874
1987	12	4878	804	1380	188	173	153	41	23	18	7670
1988	-	1345	5662	688	1076	175	100	86	21	18	9171
1989	-	1770	2638	3237	207	362	51	20	13	-	8298
1990	-	4603	3273	1265	1465	134	143	28	3	8	10922
1991	41	1032	2731	2040	873	572	52	23	8	3	7375
U.S. Commercial Landings in Weight (mt) at Age											
1978	-	430	14159	6041	2794	276	2168	274	356	81	26579
1979	30	2462	1411	17662	4525	2943	541	2507	-	564	32645
1980	74	4475	11663	1141	10937	6375	3504	657	1227	-	40053
1981	22	4592	8528	6644	524	7532	2773	716	1628	890	33849
1982	249	10960	7032	6465	6856	755	4281	1200	624	911	39333
1983	80	5303	13647	4271	4015	4628	679	2244	975	914	36756
1984	85	2099	8096	10650	2655	2655	3456	246	1739	1234	32915
1985	118	6094	3320	3930	7219	1746	1397	1707	148	1149	26828
1986	131	1586	7498	1475	1892	2964	528	537	507	372	17490
1987	10	6888	1953	5581	1063	1349	1306	392	242	251	19035
1988	-	2098	12981	2288	5677	1157	848	776	226	259	26310
1989	-	2958	5964	11861	1106	2403	439	209	157	-	25097
1990	-	7094	7411	4346	6902	817	1193	297	35	98	28193
1991	47	1615	6840	6943	4362	3526	406	285	96	55	24175
U.S. Commercial Landings Mean Weight (kg) at Age											
1978	-	1.298	2.470	3.692	4.473	5.199	7.522	7.924	12.794	10.125	3.043
1979	0.889	1.522	2.464	4.301	4.974	7.309	9.127	10.264	-	12.533	4.085
1980	0.839	1.490	2.478	3.992	5.792	6.703	8.489	8.648	8.046	-	3.464
1981	0.885	1.501	2.360	3.389	5.209	7.339	8.397	9.988	14.884	19.348	3.274
1982	0.767	1.395	2.852	3.845	5.449	6.457	9.473	10.297	12.434	15.982	2.736
1983	0.993	1.497	2.456	3.434	4.703	6.407	7.955	10.280	11.091	14.742	2.952
1984	1.053	1.638	2.450	3.597	5.308	6.751	8.960	9.710	11.361	15.049	3.590
1985	0.914	1.424	2.157	3.989	5.201	6.398	8.075	10.355	12.107	13.360	2.971
1986	0.957	1.454	2.279	3.414	5.608	7.198	9.066	10.135	13.339	14.308	2.978
1987	0.801	1.412	2.429	4.043	5.657	7.811	8.520	9.466	10.621	13.944	2.482
1988	-	1.559	2.293	3.326	5.278	6.629	8.487	9.067	10.606	14.389	2.869
1989	-	1.672	2.260	3.664	5.351	6.632	8.686	10.673	11.622	-	3.025
1990	-	1.541	2.264	3.436	4.712	6.103	8.366	10.482	10.246	12.250	2.581
1991	1.131	1.566	2.504	3.403	4.955	6.161	7.829	12.392	11.991	20.861	3.278
U.S. Commercial Landings Mean Length (cm) at Age											
1978	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	107.1	101.0	64.9
1979	44.7	52.9	61.0	73.9	77.5	88.2	95.3	99.4	-	106.1	70.9
1980	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	-	66.5
1981	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	112.8	123.2	64.6
1982	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	105.5	114.9	60.7
1983	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	101.5	111.7	63.3
1984	47.2	54.1	61.5	69.8	79.3	86.5	94.8	97.5	102.5	112.0	67.7
1985	45.1	51.8	58.6	72.4	79.0	84.5	91.4	99.4	104.7	107.9	62.5
1986	45.8	52.0	60.1	67.6	81.1	88.2	95.2	98.7	108.2	109.8	63.2
1987	43.3	51.7	61.3	72.7	81.6	90.9	93.2	96.6	100.1	110.1	59.4
1988	-	53.6	60.3	67.6	79.2	85.5	92.7	94.8	100.1	109.6	63.4
1989	-	54.7	60.1	70.0	79.3	85.3	94.2	100.4	103.6	-	64.8
1990	-	53.4	59.8	68.6	76.1	82.7	92.2	99.7	99.3	106.0	61.1
1991	48.4	53.5	62.1	68.0	77.5	82.8	90.0	106.1	105.7	125.8	66.3

Table 6. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of Canadian commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978-1991

	Age										
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Total**
Canadian Commercial Landings in Numbers (000s) at Age											
1978	2	62	2017	667	205	78	57	12	12	7	3119
1979	-	371	328	763	302	55	18	9	4	3	1853
1980	1	775	1121	214	420	125	32	11	14	10	2723
1981	2	145	608	504	134	380	87	51	21	16	1948
1982	6	1283	1358	1105	742	164	221	97	21	26	5023
1983	27	744	2506	1212	201	54	10	17	12	3	4786
1984	-	26	118	375	340	123	72	19	18	39	1130
1985	4	2146	904	383	497	139	45	38	9	11	4176
1986	19	235	1283	365	143	215	29	19	9	3	2320
1987	14	2595	602	741	91	79	117	22	15	6	4282
1988	10	232	2360	324	421	69	61	111	29	29	3646
1989	-	318	284	918	124	179	31	23	37	18	1932
1990	7	339	1769	617	799	95	102	8	14	30	3780
1991	11	493	512	1241	585	516	74	47	15	20	3514
Canadian Commercial Landings in Weight (mt) at Age											
1978	1	85	4913	1949	803	483	378	122	113	107	8778
1979	-	509	525	2842	1398	342	169	105	47	42	5978
1980	1	1041	2720	692	2099	809	228	133	177	157	8063
1981	2	197	1426	1772	699	2624	801	497	220	224	8499
1982	4	1853	3156	4217	3849	1074	2019	914	266	418	17824
1983	24	1084	5521	3854	876	335	80	176	147	37	12130
1984	-	38	292	1423	1615	743	622	202	195	620	5763
1985	3	3017	1775	1388	2370	895	368	369	94	160	10443
1986	14	369	3691	1442	800	1543	250	180	89	28	8411
1987	9	4183	1556	3302	557	596	1113	243	189	93	11845
1988	8	300	5942	1265	2406	462	564	1188	334	437	12932
1989	-	417	669	3812	678	1221	231	247	432	276	8011
1990	5	615	5001	2283	4173	631	876	85	187	454	14310
1991	12	866	1425	4278	2593	2885	527	451	127	291	13455
Candian Commercial Landings Mean Weight (kg) at Age											
1978	0.707	1.376	2.436	2.922	3.918	6.187	6.625	10.148	9.429	15.262	2.814
1979	-	1.371	1.601	3.725	4.630	6.222	9.365	11.638	11.699	14.064	3.226
1980	0.567	1.343	2.426	3.235	4.997	6.468	7.119	12.135	12.652	15.721	2.961
1981	0.839	1.362	2.345	3.516	5.216	6.905	9.204	9.747	10.465	13.993	4.363
1982	0.652	1.444	2.324	3.816	5.188	6.550	9.137	9.418	12.667	16.092	3.548
1983	0.904	1.457	2.203	3.180	4.357	6.203	8.042	10.368	12.222	12.270	2.534
1984	-	1.477	2.473	3.794	4.751	6.043	8.633	10.622	10.807	15.897	5.100
1985	0.686	1.406	1.964	3.625	4.768	6.440	8.181	9.718	10.499	14.537	2.501
1986	0.723	1.572	2.877	3.952	5.592	7.179	8.612	9.453	9.934	9.437	3.625
1987	0.661	1.612	2.584	4.456	6.125	7.540	9.510	11.031	12.629	15.444	2.766
1988	0.786	1.294	2.518	3.904	5.716	6.694	9.251	10.700	11.531	15.065	3.547
1989	-	1.310	2.356	4.153	5.471	6.820	7.459	10.757	11.680	15.356	4.141
1990	0.831	1.812	2.827	3.699	5.221	6.657	8.582	11.227	13.080	14.821	3.786
1991	1.051	1.756	2.783	3.447	4.432	5.591	7.116	9.604	8.457	14.550	3.829
Canadian Commercial Landings Mean Length (cm) at Age											
1978	39.5	48.9	59.0	63.3	69.6	81.2	82.5	98.3	94.7	112.8	61.8
1979	-	49.3	51.9	69.3	74.8	82.2	95.2	103.2	103.4	110.4	64.1
1980	36.6	48.9	59.5	66.2	76.4	83.6	86.6	104.7	105.7	114.6	61.7
1981	41.8	49.1	59.1	68.1	78.0	86.1	94.8	96.6	97.5	108.9	70.6
1982	38.3	50.1	58.9	70.0	77.8	84.4	94.9	95.2	106.4	115.3	65.5
1983	42.9	50.4	57.9	65.8	73.0	82.9	90.9	99.0	105.1	105.0	59.9
1984	-	50.7	60.4	70.0	75.7	82.3	92.3	100.1	100.8	114.5	75.6
1985	39.0	49.8	55.7	68.7	75.3	83.8	91.1	96.3	99.0	110.8	58.1
1986	39.6	51.7	63.5	71.0	79.6	86.8	92.8	95.9	96.3	96.1	67.2
1987	38.5	52.1	61.0	73.6	82.3	88.4	96.1	101.2	106.3	114.4	60.1
1988	40.8	48.3	60.5	70.4	80.2	84.8	95.2	99.9	102.5	112.2	65.8
1989	-	48.6	59.1	71.9	79.0	85.1	87.7	100.3	103.1	113.3	69.4
1990	41.7	54.3	63.1	69.0	77.6	84.0	92.0	102.0	107.4	112.1	68.2
1991	45.1	53.7	62.6	67.2	73.3	78.8	86.2	96.1	90.6	112.1	68.4

Table 7. Landings at age (thousands of fish, metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Statistical Area 6), 1978-1991

Year	Age 1	2	3	4	5	6	7	8	9	10+	Total	% of Total Landings USA	Canada
Total Commercial Landings in Numbers (000s) at Age													
1978	2	393	7748	2303	830	131	345	47	40	15	11854	73.7	26.3
1979	34	1989	900	4870	1212	458	77	253	4	48	9845	81.2	18.8
1980	89	3777	5828	500	2308	1076	445	87	167	10	14287	80.9	19.1
1981	27	3205	4221	2464	235	1406	417	123	130	62	12290	84.1	15.9
1982	331	9138	3824	2787	2000	281	673	213	71	83	19401	74.1	25.9
1983	108	4286	8063	2456	1055	776	95	235	100	65	17239	72.2	27.8
1984	81	1307	3423	3336	840	516	458	44	171	121	10297	89.0	11.0
1985	134	6426	2443	1368	1885	412	218	203	21	97	13207	68.4	31.6
1986	156	1326	4573	797	480	627	87	72	47	29	8194	71.7	28.3
1987	26	7473	1406	2121	279	252	270	63	38	24	11952	64.2	35.8
1988	10	1577	8022	1012	1497	244	161	197	50	47	12817	71.6	28.4
1989	-	2088	2922	4155	331	541	82	43	50	18	10230	81.1	18.9
1990	7	4942	5042	1882	2264	229	245	36	17	38	14702	74.3	25.7
1991	52	1525	3243	3281	1458	1088	126	70	23	23	10889	67.7	32.3
Total Commercial Landings in Weight (Tons) at Age													
1978	1	515	18890	7990	3597	757	2549	395	465	198	35357	75.2	24.8
1979	30	2970	1936	20504	5923	3288	711	2611	44	606	38623	84.5	15.5
1980	75	5516	14382	1833	13036	7184	3735	793	1408	154	48116	83.2	16.8
1981	24	4789	9953	8416	1224	10156	3575	1212	1848	1151	42348	79.9	20.1
1982	253	12812	10187	10681	10705	1827	6303	2110	891	1388	57157	68.8	31.2
1983	105	6387	19167	8126	4891	4963	763	2418	1120	946	48886	75.2	24.8
1984	85	2137	8389	12074	4271	3401	4078	447	1938	1858	38678	85.1	14.9
1985	121	9111	5095	5319	9588	2644	1765	2073	246	1309	37271	72.0	28.0
1986	145	1955	11189	2917	2692	4505	776	717	596	409	25901	67.5	32.5
1987	19	11071	3509	8882	1619	1945	2416	633	426	360	30880	61.6	38.4
1988	8	2399	18923	3552	8085	1618	1412	1960	566	719	39242	67.0	33.0
1989	-	3375	6633	15673	1783	3625	669	455	588	298	33098	75.8	24.2
1990	5	7709	12412	6629	11075	1448	2069	382	222	552	42503	66.3	33.7
1991	59	2481	8265	11221	6955	6411	933	736	223	346	37630	64.2	35.8
Total Commercial Landings Mean Weight (kg) at Age													
1978	0.707	1.310	2.461	3.469	4.336	5.787	7.374	8.492	11.785	13.200	2.983		
1979	0.889	1.494	2.149	4.211	4.888	7.178	9.183	10.313	11.699	12.625	3.923		
1980	0.836	1.460	2.468	3.668	5.647	6.676	8.390	9.089	8.432	15.400	3.368		
1981	0.882	1.495	2.358	3.415	5.213	7.222	8.565	9.888	14.170	18.565	3.446		
1982	0.765	1.402	2.664	3.834	5.352	6.511	9.363	9.897	12.503	16.723	2.946		
1983	0.971	1.490	2.377	3.309	4.637	6.393	7.964	10.286	11.227	14.554	2.836		
1984	1.053	1.635	2.451	3.619	5.083	6.582	8.909	10.104	11.303	15.356	3.756		
1985	0.907	1.418	2.086	3.887	5.087	6.412	8.097	10.236	11.418	13.494	2.822		
1986	0.929	1.475	2.447	3.660	5.603	7.191	8.915	9.955	12.687	14.104	3.161		
1987	0.726	1.481	2.495	4.187	5.810	7.726	8.949	10.013	11.414	15.000	2.584		
1988	0.786	1.520	2.359	3.511	5.401	6.647	8.776	9.987	11.143	15.298	3.062		
1989	-	1.617	2.269	3.772	5.396	6.694	8.222	10.718	11.665	17.111	3.235		
1990	0.831	1.560	2.462	3.522	4.892	6.333	8.456	10.648	12.580	14.526	2.891		
1991	1.114	1.627	2.548	3.420	4.769	5.891	7.410	10.520	9.686	15.373	3.456		
Total Commercial Landings Mean Length (cm) at Age													
1978	39.5	50.0	60.8	67.9	72.7	80.4	80.2	93.1	103.4	106.5	64.1		
1979	44.7	52.2	57.7	73.2	76.8	87.5	95.3	99.5	103.4	106.4	69.6		
1980	43.8	51.8	61.2	69.7	80.9	86.0	92.4	93.8	92.4	114.6	65.6		
1981	44.4	52.2	60.2	68.4	78.2	88.0	93.5	97.5	110.3	119.5	65.6		
1982	42.2	51.2	62.4	70.5	79.1	84.3	96.0	97.4	105.8	115.0	61.9		
1983	45.5	52.3	60.4	67.0	75.3	84.4	90.7	99.1	101.9	111.4	62.4		
1984	47.2	54.0	61.5	69.8	77.8	85.5	94.4	98.6	102.3	112.8	68.6		
1985	44.9	51.1	57.5	71.4	78.0	84.3	91.3	98.8	102.3	108.2	61.1		
1986	45.0	51.9	61.1	69.2	80.7	87.7	94.4	98.0	105.9	108.4	64.3		
1987	40.7	51.8	61.2	73.0	81.8	90.1	94.5	98.2	102.5	111.2	59.7		
1988	40.8	52.8	60.4	68.5	79.5	85.3	93.6	97.7	101.5	111.2	64.1		
1989	-	53.8	60.0	70.4	79.2	85.2	91.7	100.3	103.2	113.3	65.7		
1990	41.7	53.5	61.0	68.7	76.6	83.2	92.1	100.2	106.0	110.8	62.9		
1991	47.7	53.6	62.2	67.7	75.8	80.9	87.8	99.4	95.9	113.9	67.0		

Table 8. Summary of U.S. and Canadian 1991 commercial landings of Atlantic cod from the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6)

	U.S. Catch at Age				Canadian Catch at Age				Total 1991 Catch at Age			
Age	Catch in Numbers (000s)	% of U.S. Total	Catch in Weight (mt)	% of U.S. Total	Catch in Numbers (000s)	% of Can. Total	Catch in Weight (mt)	% of Can. Total	Catch in Numbers (000s)	% of Total	Catch in Weight (mt)	% of Total
1	41	0.6	47	0.2	11	0.3	12	0.1	52	0.5	59	0.2
2	1032	14.0	1615	6.7	493	14.0	866	6.4	1525	14.0	2481	6.6
3	2731	37.0	6840	28.3	512	14.6	1425	10.6	3243	29.8	8265	22.0
4	2040	27.7	6943	28.7	1241	35.3	4278	31.8	3281	30.1	11221	29.8
5	873	11.8	4362	18.0	585	16.6	2593	19.3	1458	13.4	6955	18.5
6	572	7.8	3526	14.6	516	14.7	2885	21.4	1088	10.0	6411	17.0
7	52	0.7	406	1.7	74	2.1	527	3.9	126	1.2	933	2.5
8	23	0.3	285	1.2	47	1.3	451	3.4	70	0.6	736	2.0
9+	11	0.1	151	0.6	35	1.0	418	3.1	46	0.4	569	1.5
Total	7375	100.0	24175	100.0	3514	100.0	13455	100.0	10889	100.0	37630	100.0
	Mean Weight Per Fish (kg) 3.28				Mean Weight Per Fish (kg) 3.83				Mean Weight Per Fish (kg) 3.46			

Table 9. Mean weight at age (kg) at the beginning of the year (January 1) for Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978-1992. Values derived from catch mean weight at age data (mid-year) using procedures described by Rivard (1980).

	Year														
Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.486	0.694	0.625	0.700	0.548	0.748	0.907	0.711	0.736	0.502	0.548	0.583	0.594	1.067	0.659
2	1.023	1.028	1.139	1.118	1.112	1.068	1.260	1.222	1.157	1.173	1.050	1.127	1.123	1.163	1.163
3	1.881	1.678	1.920	1.855	1.996	1.826	1.911	1.847	1.863	1.918	1.869	1.857	1.995	1.994	2.277
4	2.922	3.219	2.808	2.903	3.007	2.969	2.933	3.087	2.763	3.201	2.960	2.983	2.827	2.902	3.256
5	3.370	4.118	4.876	4.373	4.275	4.216	4.101	4.291	4.667	4.611	4.755	4.353	4.296	4.098	4.031
6	4.594	5.579	5.712	6.386	5.826	5.849	5.525	5.709	6.048	6.579	6.214	6.013	5.846	5.368	5.549
7	6.235	7.290	7.760	7.562	8.223	7.201	7.547	7.300	7.561	8.022	8.234	7.393	7.524	6.850	6.465
8	7.235	8.721	9.136	9.108	9.207	9.814	8.970	9.549	8.978	9.448	9.454	9.699	9.357	9.432	8.015
9	10.004	9.967	9.325	11.349	11.119	10.541	10.783	10.741	11.396	10.660	10.563	10.793	11.612	10.156	11.734
10+	13.200	12.625	15.400	18.565	16.723	14.554	15.356	13.494	14.104	15.000	15.298	17.111	14.526	15.373	15.373

dominant in the U.S. fishery than in the Canadian fishery; the 1988 cohort accounted for 37% of the U.S. landings in number, but only 15% of the Canadian landings. The 1987 year class dominated the 1991 Canadian landings (35% by number; 32% by weight), with the 1985 and 1986 cohorts being the next most important in terms of weight and numbers, respectively.

MEAN WEIGHTS AT AGE

Mean weights at age in the landings for ages 1 to 10+ during 1978-1991 are given in Table 7 and, based on landings patterns, are considered mid-year values. Although no consistent trends in size or weight at age are evident over the 14-year time series, mean weights in 1990 and 1991 for age groups 2 and 3 were among the highest on record, while mean weights for age groups 4 to 6 in 1990-1991 were near the lowest on record. Both the U.S. and Canadian landings exhibited these patterns, although the changes are more pronounced in the Canadian data.

Mean weights at age for calculating stock biomass at the beginning of the year are provided in Table 9. These values were derived from the catch mean weights at age data (Table 7) using the procedures described by Rivard (1980).

STOCK ABUNDANCE AND BIOMASS INDICES

COMMERCIAL CATCH RATES

United States commercial LPUE indices (landings per unit effort, expressed in metric tons landed per day fished) were calculated, by tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), from otter trawl trips landing cod from Georges Bank (Subdivision 5Ze). Indices were derived based on all trips landing cod, and for 'directed trips' in which cod constituted 50% or more of the total trip catch by weight (Tables 10 and 11). Directed trips have accounted for greater than 50% (and as high as 79%) of U.S. Georges Bank otter trawl landings of cod since 1973 (Table 12). In 1991, directed trips accounted for 72% of the U.S. landings. In the past four years (1988-1991), the U.S. fishery for cod has become highly directed (*i.e.*, near 75% of the U.S. otter trawl landings of cod are taken in directed trips).

Since 1970, both total and directed U.S. LPUE indices have generally exhibited similar trends (Table 10; Figure 2). LPUE values for Class 3 and 4 vessels (which account for more than 95% of the U.S. otter trawl landings of Georges Bank cod) generally increased during the early 1970s, leveled off during the mid-1970s, and then sharply increased attaining peak levels in the late 1970s. Subsequently, LPUE indices trended downward until 1988 when both total and directed indices increased. In 1990, LPUE values again increased, but both LPUE indices declined slightly in 1991. Taken at face value, the 1990-1991 LPUE indices suggest that the exploitable stock biomass of cod during the past two years was higher than during 1987-1989. Canadian LPUE indices are not considered to be reliable indicators of stock abundance (Hunt 1990), and have not been used in any of the recent Canadian assessments of the Georges Bank cod stock (Hunt and Buzeta 1992).

In terms of 'calculated effort' (total landings/total U.S. LPUE index), both total and U.S. fishing effort peaked at record-high levels in 1988, declined in 1989, and have since stabilized at a level about 10% below the 1988 peak (Table 13).

Fishing effort was standardized by applying a five-factor (year, month, tonnage class, area, and depth) General Linear Model (GLM) to log LPUE data derived for all otter trawl trips taking cod from 1978 through 1991 (Table 14). The model accounted for just over 30% of the total sum of squares, although all five factors were highly significant. Retransformed log year coefficients were multiplied by the 1978 base year LPUE (from Table 10) and divided into the annual U.S. landings (from Table 13) to derive standardized effort values [given at the bottom right of Table 14]. However, the model may not account for all changes in catchability due to increases in technology. Both series of U.S. effort estimates (Tables 13 and 14) show the same trends over time, with peak U.S. effort occurring in 1985 followed by a decline in 1986 and 1987. Although effort in both series increased in 1988, the GLM standardized series indicates that effort stabilized during 1989-1991 while the calculated series indicates that effort declined by about 5% per year during the 1989-1991 period (Figure 3).

Given the differences in the two methods used for computing fishing effort, it is not surprising that the two methods produce slightly different results. The GLM method accounts for spatial and seasonal effects, as well as tonnage class differences. The calculated effort approach does not explicitly consider these factors and hence may be more sensitive to changes in fleet directivity. The increased directivity of the U.S. fishery to high levels during 1988-1991 probably inflates the 'all cod trips' U.S. LPUE indices in the most recent years since a greater proportion of the total cod landings is currently represented by directed trips. Hence, the 'calculated U.S. effort' values for 1988-1991 should probably be considered as underestimates.

RESEARCH VESSEL SURVEY INDICES

Indices of cod abundance (stratified mean catch per tow in numbers) and biomass (stratified mean weight per tow in kilograms) derived from Northeast Fisheries Science Center (NEFSC) research vessel bottom trawl surveys have been used to monitor changes and assess trends in population size and recruitment of U.S. cod stocks since 1963. Offshore (≥27 m) stratified random NEFSC surveys on Georges Bank have been conducted annually in the autumn since 1963, and in the spring since 1968 (Azarovitz 1981; Clark 1981). Inshore areas (<27 m) have been sampled since 1978 during spring and autumn NEFSC inshore surveys and since 1978 during Commonwealth of Massachusetts (MASS) spring and autumn inshore bottom trawl surveys. For the NEFSC surveys, a 36 Yankee trawl has been the standard sampling gear except for spring 1973-1981 when a modified 41 Yankee trawl was used.

Table 10. U.S. commercial landings (L)[1], days fished (DF)[2], and landings per day fished (LPUE), by vessel tonnage class (Class 2: 2 to 50 GRT; Class 3: 51 to 150 GRT; Class 4: 151-500 GRT), of Atlantic cod for otter trawl trips catching cod from Georges Bank (NAFO Division 5Ze), 1965-1991. Data are also provided for otter trawl trips in which cod constituted 50% or more of the total trip catch by weight ('directed trips').

	Class 2			Class 3			Class 4			Totals	
Year	L	DF	LPUE	L	DF	LPUE	L	DF	LPUE	L	LPUE[3]
					All Trips						
1965	487	1661	0.29	5201	9719	0.54	4351	4175	1.04	10039	0.74
1966	386	1555	0.25	4754	10505	0.45	4731	4510	1.05	9871	0.73
1967	437	1069	0.41	5292	8570	0.62	4519	3789	1.19	10248	0.86
1968	321	570	0.56	6861	8534	0.80	4903	3397	1.44	12085	1.05
1969	433	500	0.87	7942	7953	1.00	4819	2783	1.73	13194	1.26
1970	508	535	0.95	6729	8296	0.81	4033	2218	1.82	11270	1.18
1971	563	681	0.83	7652	8808	0.87	4215	2195	1.92	12430	1.22
1972	524	721	0.73	6382	9257	0.69	3274	1766	1.85	10180	1.07
1973	322	550	0.59	7814	8668	0.90	4295	1701	2.52	12431	1.45
1974	585	617	0.95	8222	9438	0.87	5266	2097	2.51	14073	1.49
1975	509	534	0.95	7029	8684	0.81	4527	2085	2.17	12065	1.33
1976	421	474	0.89	7861	7791	1.01	3969	1469	2.70	12251	1.55
1977	850	607	1.40	13250	9492	1.40	4423	1472	3.00	18523	1.78
1978	1165	715	1.63	14853	9411	1.58	4829	1551	3.11	20847	1.94
1979	956	658	1.45	18377	9924	1.85	7116	2507	2.84	26449	2.10
1980	1062	882	1.20	21331	10961	1.95	10053	3726	2.70	32446	2.16
1981	1184	845	1.40	17025	10615	1.60	9404	3797	2.48	27613	1.89
1982	1406	695	2.02	20468	10717	1.91	11450	4296	2.67	33324	2.18
1983	835	429	1.95	17112	10694	1.60	13011	5116	2.54	30958	2.00
1984	375	427	0.88	14883	13605	1.09	10899	5746	1.90	26157	1.42
1985	370	453	0.82	12852	13629	0.94	8215	5501	1.49	21437	1.15
1986	150	233	0.64	8014	10442	0.77	5411	4354	1.24	13575	0.96
1987	108	220	0.49	8505	12067	0.70	5090	4770	1.07	13703	0.84
1988	100	233	0.43	12808	13791	0.93	7345	5799	1.27	20253	1.05
1989	144	320	0.45	10104	13151	0.77	7631	5274	1.45	17879	1.06
1990	141	260	0.54	11586	13567	0.85	9891	5552	1.78	21618	1.27
1991	89	239	0.37	9067	12843	0.71	8716	5472	1.59	17872	1.14
					50% Trips						
1965	18	8	2.25	353	86	4.10	819	159	5.15	1190	4.79
1966	7	<1	-	370	88	4.20	991	199	4.98	1368	4.74
1967	33	17	1.94	874	238	3.67	1464	318	4.60	2371	4.22
1968	16	3	5.33	1665	464	3.59	1442	328	4.40	3123	3.97
1969	73	9	8.11	2612	773	3.38	1475	359	4.11	4160	3.72
1970	164	25	6.56	1695	534	3.17	1739	388	4.48	3598	3.96
1971	117	15	7.80	2232	721	3.10	2163	494	4.38	4512	3.84
1972	152	54	2.81	2137	716	2.98	1879	445	4.22	4168	3.53
1973	52	16	3.25	3242	820	3.95	3010	486	6.19	6304	5.01
1974	259	119	2.18	3707	1115	3.32	3899	703	5.55	7865	4.39
1975	246	85	2.89	2678	842	3.18	3128	585	5.35	6052	4.29
1976	159	66	2.41	3665	1089	3.37	2664	464	5.74	6488	4.32
1977	502	120	4.18	6595	1342	4.91	2899	373	7.77	9996	5.70
1978	846	215	3.93	6554	1644	3.99	2427	330	7.35	9827	4.81
1979	612	168	3.64	9714	2558	3.80	4270	840	5.08	14596	4.17
1980	644	196	3.29	11727	2909	4.03	5616	1067	5.26	17987	4.39
1981	766	153	5.01	9414	2591	3.63	4312	953	4.52	14492	3.97
1982	1046	212	4.93	14724	3631	4.06	7791	1521	5.12	23561	4.45
1983	566	130	4.35	11884	3033	3.92	8795	1872	4.70	21245	4.25
1984	140	55	2.55	9156	3454	2.65	6620	1918	3.45	15916	2.98
1985	184	65	2.83	8725	4346	2.01	6053	2330	2.60	14962	2.26
1986	58	18	3.22	5258	2969	1.77	3755	1406	2.67	9071	2.15
1987	36	18	2.00	5743	3874	1.48	3354	1781	1.88	9133	1.63
1988	37	22	1.68	9974	6457	1.54	5527	2731	2.02	15538	1.71
1989	66	56	1.18	7864	6023	1.31	6200	3083	2.01	14130	1.62
1990	61	16	3.81	8490	4965	1.71	8151	3204	2.54	16702	2.12
1991	27	12	2.25	6110	4358	1.40	6647	2633	2.52	12784	1.98

[1] **Metric tons, live weight.**

[2] **Days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.**

[3] **Total LPUE was derived by weighting individual tonnage class LPUE values by the percentage of total landings accounted for by each vessel class and summing over the three vessel class categories.**

Table 11. United States commercial vessel trips (T), days fished (DF)[1], and average days fished per trip (DF/T), by vessel tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), for otter trawl trips catching Atlantic cod from Georges Bank (NAFO Subdivision 5Ze), 1965 - 1991. Data are also provided for otter trawl trips in which cod constituted 50% or more of the total trip catch, by weight ['directed trips'].

	Class 2			Class 3			Class 4			Totals		
Year	T	DF	DF/T	T	DF	DF/T	T	DF	DF/T	T	DF	DF/T
						All Trips						
1965	897	1661	1.85	2885	9719	3.37	886	4175	4.71	4668	15555	3.33
1966	873	1555	1.78	3173	10505	3.31	970	4510	4.65	5016	16570	3.30
1967	824	1069	1.30	2810	8570	3.05	875	3789	4.33	4509	13428	2.98
1968	508	570	1.12	2600	8534	3.28	789	3397	4.31	3897	12501	3.21
1969	330	500	1.52	2428	7953	3.28	637	2783	4.37	3395	11236	3.31
1970	412	535	1.30	2614	8296	3.17	614	2218	3.61	3640	11049	3.04
1971	680	681	1.00	2524	8808	3.49	538	2195	4.08	3742	11684	3.12
1972	628	721	1.15	2544	9257	3.64	468	1766	3.77	3640	11744	3.23
1973	412	550	1.33	2491	8668	3.48	510	1701	3.34	3413	10919	3.20
1974	606	617	1.02	2561	9438	3.69	613	2097	3.42	3780	12152	3.21
1975	471	534	1.13	2491	8684	3.49	637	2085	3.27	3599	11303	3.14
1976	359	474	1.32	2281	7791	3.42	478	1469	3.07	3118	9734	3.12
1977	561	607	1.08	3177	9492	2.99	572	1472	2.57	4310	11571	2.68
1978	845	715	0.85	3457	9411	2.72	654	1551	2.37	4956	11677	2.36
1979	577	658	1.14	4389	9924	2.26	1119	2507	2.24	6085	13089	2.15
1980	726	882	1.21	4868	10961	2.25	1324	3726	2.81	6918	15569	2.25
1981	810	845	1.04	4036	10615	2.63	1276	3797	2.98	6122	15257	2.49
1982	799	695	0.87	3892	10717	2.75	1209	4296	3.55	5900	15708	2.66
1983	522	429	0.82	3336	10694	3.21	1299	5116	3.94	5157	16239	3.15
1984	488	427	0.88	3723	13605	3.65	1322	5746	4.35	5533	19778	3.57
1985	426	453	1.06	3556	13629	3.83	1216	5501	4.52	5198	19583	3.77
1986	340	233	0.69	2699	10442	3.87	1018	4354	4.28	4057	15029	3.70
1987	314	220	0.70	3044	12067	3.96	1117	4770	4.27	4475	17057	3.81
1988	278	223	0.80	3297	13791	4.18	1283	5799	4.52	4858	19813	4.08
1989	335	320	0.96	3143	13151	4.18	1232	5273	4.28	4710	18744	3.98
1990	271	260	0.96	3150	13567	4.31	1324	5552	4.19	4745	19379	4.08
1991	189	239	1.26	2808	12843	4.57	1225	5472	4.47	4222	18554	4.39
						50% Trips						
1965	9	8	0.89	54	86	1.59	47	159	3.38	110	253	2.30
1966	1	<1	-	45	88	1.96	63	199	3.16	109	287	2.63
1967	11	17	1.55	111	238	2.14	101	318	3.15	223	573	2.57
1968	5	3	0.60	153	464	3.03	97	328	3.38	255	795	3.12
1969	17	9	0.53	244	773	3.17	88	359	4.08	349	1141	3.27
1970	43	25	0.58	190	534	2.81	120	388	3.23	353	947	2.68
1971	47	15	0.32	210	721	3.43	130	494	3.80	387	1230	3.18
1972	55	54	0.98	247	716	2.90	118	445	3.77	420	1215	2.89
1973	14	16	1.14	267	820	3.07	160	486	3.04	441	1322	3.00
1974	67	119	1.78	356	1115	3.13	232	703	3.03	655	1937	2.96
1975	50	85	1.70	306	842	2.75	209	585	2.80	565	1512	2.68
1976	40	66	1.65	386	1089	2.82	168	464	2.76	594	1619	2.73
1977	87	120	1.38	601	1342	2.23	167	373	2.23	855	1835	2.15
1978	186	215	1.16	781	1644	2.10	184	330	1.79	1151	2189	1.90
1979	121	168	1.39	1227	2558	2.08	396	840	2.12	1744	3566	2.04
1980	153	196	1.28	1309	2909	2.22	457	1067	2.33	1919	4172	2.17
1981	171	153	0.89	1050	2591	2.47	348	953	2.74	1569	3697	2.36
1982	191	212	1.11	1329	3631	2.73	469	1521	3.24	1989	5364	2.70
1983	102	130	1.27	970	3033	3.13	505	1872	3.71	1577	5035	3.19
1984	34	55	1.62	963	3454	3.59	465	1918	4.12	1462	5427	3.71
1985	37	65	1.76	1059	4346	4.10	509	2330	4.58	1605	6741	4.20
1986	27	18	0.67	746	2969	3.98	331	1406	4.25	1104	4393	3.98
1987	11	18	1.64	887	3874	4.37	406	1781	4.39	1304	5673	4.35
1988	15	22	1.47	1427	6457	4.52	589	2731	4.64	2031	9210	4.53
1989	29	56	1.93	1353	6023	4.45	700	3083	4.40	2082	9162	4.40
1990	23	16	0.70	1172	4965	4.24	742	3204	4.32	1937	8185	4.23
1991	15	12	0.80	978	4358	4.46	646	2633	4.08	1639	7003	4.27

[1] **Days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.**

Table 12. Percentage, within vessel tonnage class[1], of Atlantic cod otter trawl landings (L)[2], vessel trips (T), and effort (DF)[3] from Georges Bank (NAFO Division 5Ze) accounted for by otter-trawl trips in which cod constituted 50% or more of the total trip catch by weight ('directed trips'), 1965-1991.

	Class 2			Class 3			Class 4			Totals		
Year	L	T	DF	L	T	DF	L	T	DF	L	T	DF
1965	3.7	1.0	0.5	6.8	1.9	0.9	18.8	5.3	3.8	11.9	2.4	1.6
1966	1.8	0.1	<0.1	7.8	1.4	0.8	20.9	6.5	4.4	13.9	2.2	1.7
1967	7.6	1.3	1.6	16.5	4.0	2.8	32.4	11.5	8.4	23.1	4.9	4.3
1968	5.0	1.0	0.5	24.3	5.9	5.4	29.4	12.3	9.7	25.8	6.5	6.4
1969	16.9	5.2	1.8	32.9	10.0	9.7	30.6	13.8	12.9	31.5	10.3	10.2
1970	32.3	10.4	4.7	25.2	7.3	6.4	43.1	19.5	17.5	31.9	9.7	8.6
1971	20.8	6.9	2.2	29.2	8.3	8.2	51.3	24.2	22.5	36.3	10.3	10.5
1972	29.0	8.8	7.5	33.5	9.7	7.7	57.4	25.2	25.2	40.9	11.5	10.3
1973	16.1	3.4	2.9	41.5	10.7	9.5	70.1	31.4	28.6	50.7	12.9	12.1
1974	44.3	11.1	19.3	45.1	13.9	11.8	74.0	37.8	33.5	55.9	17.3	15.9
1975	48.3	10.6	15.9	38.1	12.3	9.7	69.1	32.8	28.1	50.2	15.7	13.4
1976	37.8	11.1	13.9	46.6	16.9	14.0	67.1	35.1	31.6	53.0	19.1	16.6
1977	59.1	15.5	19.8	49.8	18.9	14.1	65.5	29.2	25.3	54.0	19.8	15.9
1978	72.6	22.0	30.1	44.1	22.6	17.5	50.3	28.1	21.3	47.1	23.2	18.7
1979	64.0	21.0	25.5	52.9	28.0	25.8	60.0	35.4	33.5	55.2	28.7	27.2
1980	60.6	21.1	22.2	55.0	26.9	26.5	55.9	34.5	28.6	55.4	27.7	26.8
1981	64.7	21.1	18.1	55.3	26.0	24.4	45.9	27.3	25.1	52.5	25.6	24.2
1982	74.4	23.9	30.5	71.9	34.1	33.9	68.0	38.8	35.4	70.7	33.7	34.1
1983	67.8	19.5	30.3	69.4	29.1	28.4	67.6	38.9	36.6	68.6	30.6	31.0
1984	37.3	7.0	12.9	61.5	25.9	25.4	60.7	35.2	33.4	60.8	26.4	27.4
1985	49.7	8.7	14.3	67.9	29.8	31.9	73.7	41.9	42.4	69.8	30.9	34.4
1986	38.7	7.9	7.7	65.6	27.6	28.4	69.4	32.5	32.3	66.8	27.2	29.2
1987	33.3	3.5	8.2	67.5	29.1	32.1	65.9	36.3	37.3	66.6	29.1	33.3
1988	37.0	5.4	9.9	77.9	43.3	46.8	75.2	45.9	47.1	76.7	41.8	46.5
1989	45.8	8.7	17.5	77.8	43.0	45.8	81.2	56.8	58.5	79.0	44.2	48.9
1990	43.3	8.5	6.2	73.3	37.2	36.6	82.4	56.0	57.7	77.3	40.8	42.2
1991	30.3	7.9	5.0	67.4	34.8	33.9	76.3	52.7	48.1	71.5	38.8	37.7

[1] **Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT.**
[2] **Metric tons, live weight.**
[3] **Effort expressed as days fished with trawl on bottom; derived by dividing hours fished with trawl on bottom by 24.**

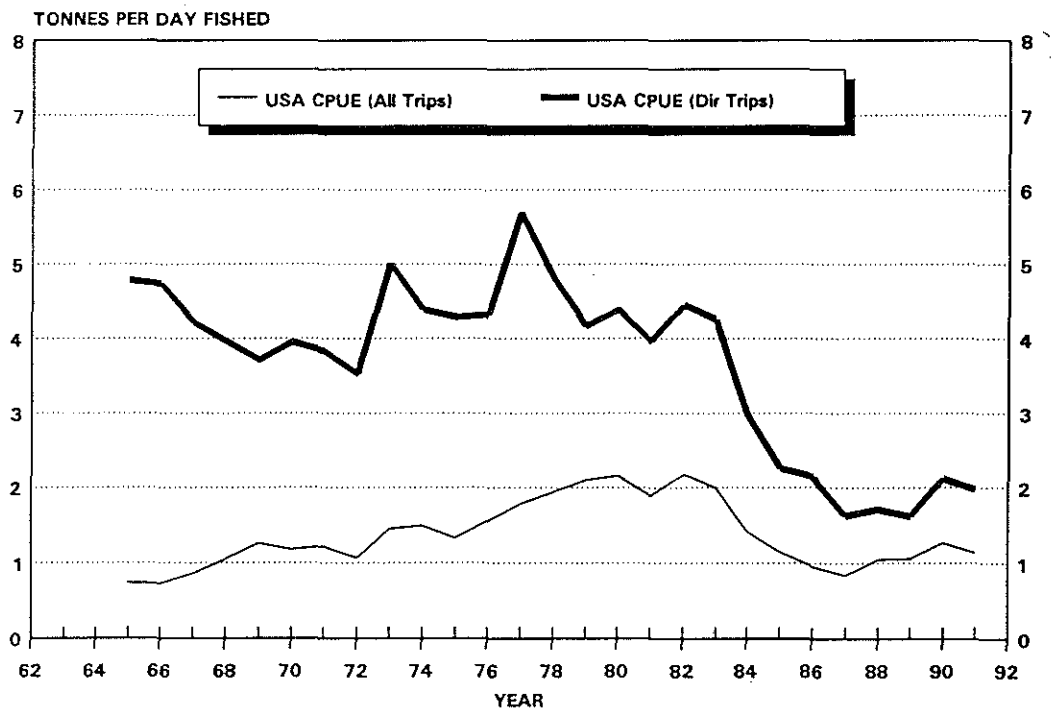

Figure 2. Trends in U.S. CPUE (landings per day fished) of Georges Bank cod, 1965-1991. Data are based on all otter trawl trips in which cod were caught (All Trips), and for otter trawl trips in which cod constituted 50% or more of the trip catch, by weight (Directed Trips).

Table 13. Total and U.S. commercial landings, U.S. landings per unit of effort indices (LPUE, all cod trips), and derived effort indices for Georges Bank cod, 1965-1991

Year	Total Landings (mt)	U.S. Landings (mt)	U.S. LPUE Index	Total Calculated Days Fished	U.S. Calculated Days Fished
1965	38333	11410	0.745	51483	15324
1966	53134	11990	0.730	72811	16430
1967	36752	13157	0.862	42616	15256
1968	43136	15279	1.053	40954	14506
1969	37939	16782	1.262	30054	13294
1970	25652	14899	1.178	21781	12650
1971	28179	16178	1.224	23018	13215
1972	25059	13406	1.065	23527	12586
1973	28923	16202	1.452	19924	11161
1974	27331	18377	1.487	18380	12358
1975	25008	16017	1.326	18857	12077
1976	19926	14906	1.553	12827	9596
1977	27367	21138	1.782	15357	11862
1978	35357	26579	1.937	18252	13720
1979	38623	32645	2.102	18375	15531
1980	48116	40053	2.158	22298	18562
1981	42348	33849	1.891	22393	17899
1982	57157	39333	2.176	26270	18078
1983	48886	36756	2.005	24388	18337
1984	38678	32915	1.424	27152	23106
1985	37271	26828	1.149	32446	23355
1986	25901	17490	0.956	27096	18386
1987	30880	19035	0.836	36947	22775
1988	39242	26310	1.051	37344	25037
1989	33098	25097	1.058	31294	23729
1990	42503	28193	1.273	33375	22138
1991	37630	24175	1.137	33082	21253

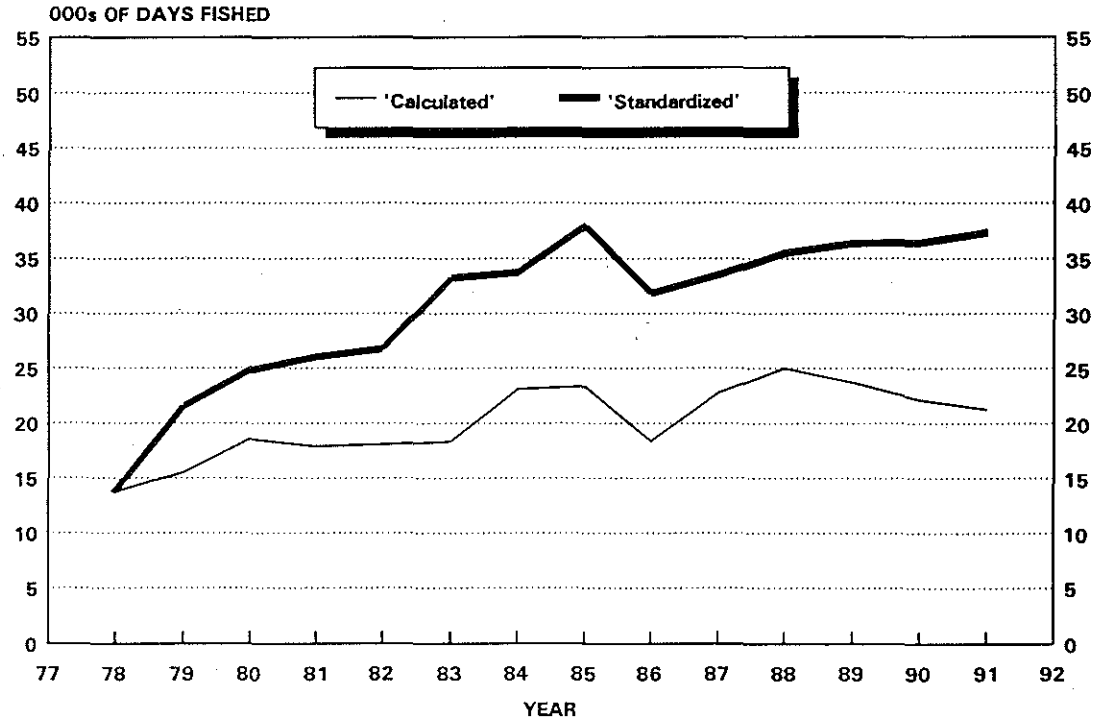

Figure 3. Trends in 'calculated' and 'standardized' U.S. fishing effort for Georges Bank cod, 1978-1991.

Table 14. General Linear Model analysis of LPUE for Georges Bank cod modeled as a function of year, vessel tonnage class, fishing area and depth, with no interactions

Georges Bank Cod Effort (Days) Standardization
Standard - Year 78; Month 5: TC 33; Area 521; Depth 3
(Using all unsummed data)

General Linear Models Procedure

Dependant Variable:	LPUE	Sum of Squares	Mean Square	F Value	PR > F	R-Square	CV
Source	DF	49957.836	110.174	562.45	0.0	0.312	9.653
Model	45	110103.178	1.974				
Error	55782	160061.014			Root MSE		LCPE Mean
Corrected Total	55827				1.405		7.149

Source	DF	Type I SS	F Value	PR > F	DF	Type II SS	F Value	PR > F
Year	13	4753.289	185.24	0.0	13	7943.760	309.58	0.0
Month	11	846.544	38.99	0.0	11	3917.533	180.43	0.0
TC	9	19681.470	1107.92	0.0	9	5311.029	298.97	0.0
Area	8	20598.750	1304.50	0.0	8	24067.576	1524.18	0.0
Depth	4	4077.783	516.49	0.0	4	4077.783	516.49	0.0

Source	DF	Type I SS	F Value	PR > F	DF	Type IV SS	F Value	PR > F
Year	13	7943.760	309.58	0.0	13	7943.760	309.58	0.0
Month	11	3917.533	180.43	0.0	11	3917.533	180.43	0.0
TC	9	5311.029	298.97	0.0	9	5311.029	298.97	0.0
Area	8	24067.576	1524.18	0.0	8	24067.576	1524.18	0.0
Depth	4	4077.783	516.49	0.0	4	4077.783	516.49	0.0

Parameter		Estimate	T for HO: Parameter=0	PR > |T|	STD Error of Estimate	Year	Re-transformed Year Coefficient	Standardized Effort (Days)
Intercept		8.47669 B	230.65	0.0	0.03675	78	1.000000	13721.73
Year	79	-0.24666 B	-7.03	0.0001	0.03511	79	0.781888	21554.72
	80	-0.18312 B	-5.43	0.0001	0.03386	80	0.832563	24836.39
	81	-0.40053 B	-11.75	0.0001	0.03409	81	0.670354	26068.25
	82	-0.27826 B	-8.38	0.0001	0.03321	82	0.757518	26806.17
	83	-0.56184 B	-16.92	0.0	0.03320	83	0.570479	33262.81
	84	-0.68683 B	-21.03	0.0	0.03266	84	0.503437	33753.52
	85	-1.00859 B	-30.85	0.0	0.03270	85	0.364928	37953.48
	86	-1.26185 B	-36.22	0.0	0.03484	86	0.283302	31872.13
	87	-1.22838 B	-36.73	0.0	0.03344	87	0.292930	33547.42
	88	-0.96205 B	-29.26	0.0	0.03288	88	0.382315	35527.90
	89	-1.03306 B	-30.56	0.0	0.03381	89	0.356120	36382.81
	90	-0.91841 B	-27.57	0.0	0.03331	90	0.399375	36444.43
	91	-0.03288 B	-32.06	0.0	0.03421	91	0.334137	37351.89
	78	0.00000 B	-	-	-			

Table 15. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963-1992[a,b,c]

	Spring		Autumn	
Year	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	4.37	17.8
1964	-	-	2.98	11.6
1965	-	-	4.25	11.7
1966	-	-	4.81	8.1
1967	-	-	10.38	13.6
1968	4.72	12.6	3.30	8.6
1969	4.64	17.8	2.20	8.0
1970	4.34	15.6	5.07	12.5
1971	3.39	14.2	3.19	9.9
1972	8.97	19.0	13.09	23.0
1973	18.68[d]	39.7 [d]	12.28	30.8
1974	14.75	36.4	3.49	8.2
1975	6.89	26.0	6.41	14.1
1976	7.06	18.6	10.44	17.7
1977	6.30	15.4	5.45	12.5
1978	12.31	31.2	8.59	23.3
1979	5.16	16.9	5.95	16.5
1980	7.75	24.9	2.91	6.7
1981	10.44	26.1	9.04	19.0
1982	8.20[e]	15.4 [e]	3.71	6.9
1983	7.70	24.0	3.64	6.5
1984	4.08	15.4	4.75	10.3
1985	6.94	21.5	2.43	3.5
1986	5.04	16.7	3.12	4.7
1987	3.26	10.3	2.33	4.4
1988	5.86	13.5	3.11	5.8
1989	4.80	10.8	4.78	4.6
1990	4.74	11.6	3.62[f]	7.1 [f]
1991	4.39	9.0	0.96	1.4
1992	2.67	7.5	1.87	3.0

[a] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).

[b] Spring surveys during 1981-1982 and 1989-1991 and autumn surveys during 1977-1981 and 1989-1991 were accomplished with the *R/V Delaware II*; in all other years, the surveys were accomplished using the *R/V Albatross IV*. Adjustments have been made to the *R/V Delaware II* catch per tow data to standardize these to *R/V Albatross IV* equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991).

[c] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data 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] Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).

Prior to 1985, BMV oval doors (550 kg) were used in all NEFSC surveys; since 1985, Portuguese polyvalent doors (450 kg) have been used. Although no adjustments were made to the NEFSC survey data for the different trawls used, adjustments have been made (Serchuk *et al.* 1991; NEFSC 1992) to the NEFSC survey catch per tow data for cod to account for the fishing power differences between the two research vessels used in the survey time series (*R/V Albatross IV* and *R/V Delaware II*) and for the differences in catchability between the BMV and polyvalent doors. All of the NEFSC survey data are now standardized in terms of *Albatross IV*, polyvalent door equivalents (Tables 15 and 16).

NEFSC spring and autumn offshore catch per tow indices for Georges Bank cod have exhibited similar trends, both in abundance and biomass, throughout the survey time series (Table 15). Survey biomass indices were relatively low and stable during 1963-1971, fluctuated at a generally higher level between 1972 and 1981, but have since declined to record-low levels (Figure 4). Large increases in the number per tow indices in 1967, 1972-73, 1976, 1978, 1981, 1985, and 1988-89 (Table 15) reflect above average recruitment of the 1966, 1971, 1975, 1977, 1978, 1980, 1983, 1985, and 1987 year classes at ages 1 and 2 (Table 16; Figure 5).

MORTALITY

NATURAL MORTALITY

Instantaneous natural mortality (M) for Georges Bank cod is assumed to be 0.20, the conventional value of M used for all Northwest Atlantic cod stocks (Paloheimo and Koehler 1968; Pinhorn 1975; Minet 1978).

TOTAL MORTALITY ESTIMATES

Pooled estimates of instantaneous total mortality (Z) were calculated for seven time periods encompassed by the NEFSC autumn and spring offshore surveys: 1964-1967, 1968-1972, 1973-1976, 1977-1981, 1982-1984, 1985-1987, and 1988-1991 (Table 17). Total mortality was calculated from survey catch per tow at age data for fully recruited age groups (age 3+) by the $\log_e$ ratio of the pooled age 3+/age 4+ indices in the autumn surveys, and the pooled age 4+/age 5+ indices in the spring surveys. For example, the 1982-1984 values were derived from:

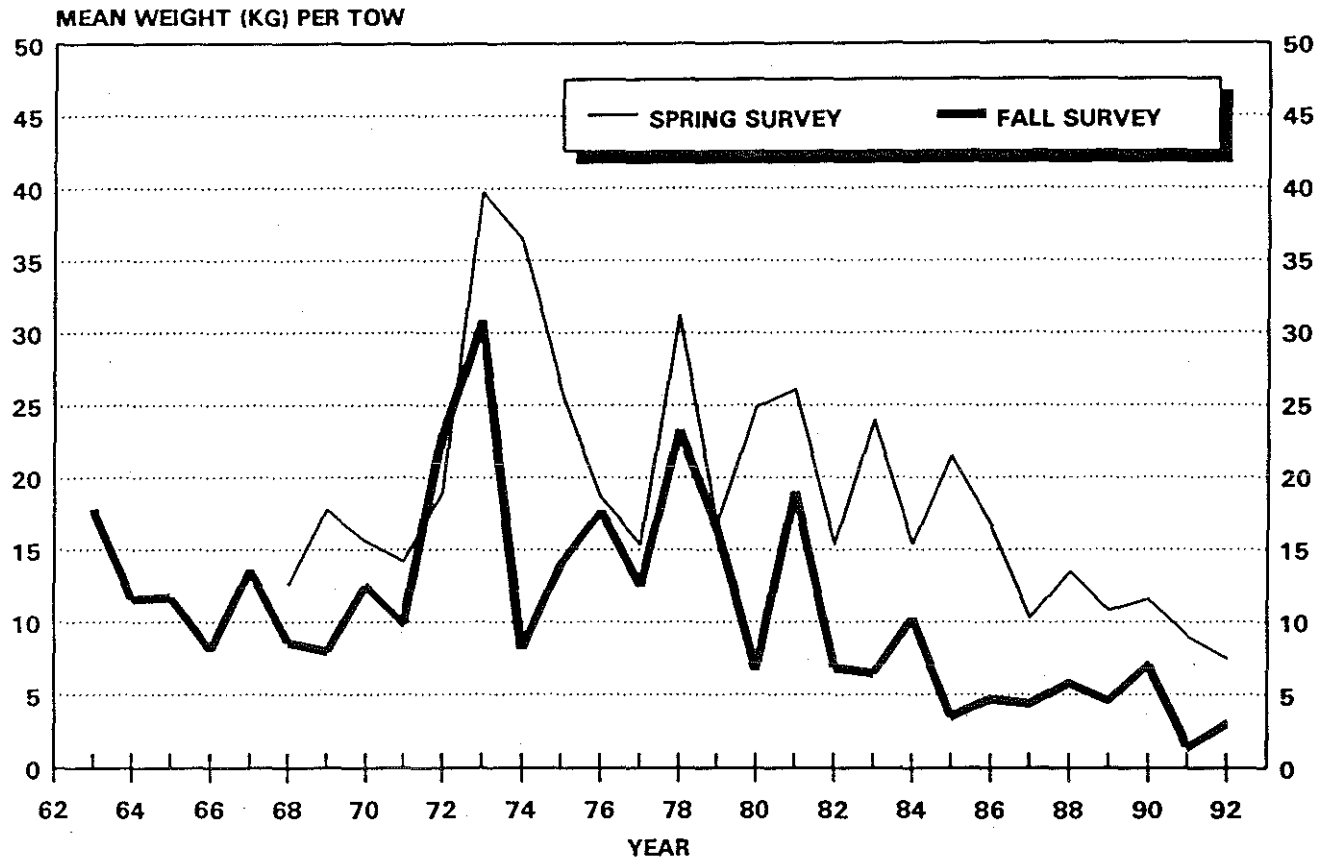

Figure 4. Standardized stratified mean catch (kg) per tow of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges bank, 1963-1992.

Autumn:

ln (Σ age 3+ for 1981-83/ Σ age 4+ for 1982-84)

Spring:

ln (Σ age 4+ for 1982-84/ Σ age 5+ for 1983-85)

Different age groups were used in the autumn and spring analyses so that Z could be evaluated over identical year classes within each time period.

The pooled estimates indicate that total mortality was high (0.73) during 1964-1967, declined significantly during 1968-1972 (0.34), increased to between 0.56 and 0.63 during 1973-1981, and peaked at record-high levels (0.68-1.10) during 1982-1987. Total mortality estimates for the most recent 1988-1991 period (0.86) are lower than those for 1985-1987, but higher than in all other time periods. Values of Z derived from the spring surveys are generally lower than those calculated from the autumn data. Rather than selecting one survey series over the other, total mortality was calculated by taking a geometric mean of the spring and autumn estimates in each time period.

ESTIMATION OF FISHING MORTALITY RATES AND STOCK SIZE

VIRTUAL POPULATION ANALYSIS

The ADAPT (Gavaris 1988, Conser and Powers 1990) calibration method was used to derive estimates of terminal F values in 1991. Several calibration formulations were evaluated. Age-disaggregated analyses were performed in each case. Parameter estimates and associated statistics and estimates of terminal F for each of the trial calibrations are given in Table 18.

A baseline ADAPT calibration was performed with NEFSC spring and autumn abundance indices and commercial CPUE indices to estimate stock sizes for ages 1 to 10 in 1992. By estimating the stock size of all ages in 1992, the F's on each age in 1991 were estimated independently without influence from adjacent ages or from the partial recruitment vector. These results produced reasonable F's on ages 1 to 6, but F's on ages 7 to 9 were either extremely high (age 9) or unexpectedly low (ages 7 and 8) given the historical partial recruitment pattern for this stock. The

Table 16. Standardized stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank, 1963-1992[a,b,c]

	Age Group											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring																	
1969	0.000	0.123	0.546	1.780	0.888	0.451	0.326	0.215	0.128	0.072	0.112	4.641	4.641	4.518	3.972	2.192	1.304
1970	0.000	0.381	0.814	0.480	1.295	0.162	0.655	0.275	0.061	0.136	0.083	4.341	4.341	3.961	3.147	2.666	1.371
1971	0.000	0.207	0.819	0.502	0.223	0.585	0.142	0.351	0.304	0.080	0.175	3.388	3.388	3.181	2.362	1.860	1.636
1972	0.056	2.902	1.833	2.641	0.510	0.119	0.324	0.122	0.220	0.115	0.125	8.967	8.911	6.009	4.176	1.535	1.025
1973[d]	0.056	0.521	11.644	2.189	2.540	0.426	0.314	0.354	0.050	0.203	0.388	18.684	18.628	18.107	6.463	4.274	1.735
1974	0.000	0.446	4.557	5.972	0.761	2.003	0.440	0.101	0.257	0.034	0.175	14.747	14.747	14.301	9.744	3.772	3.011
1975	0.000	0.064	0.378	2.042	3.092	0.261	0.686	0.129	0.094	0.108	0.039	6.892	6.892	6.828	6.451	4.409	1.317
1976	0.111	1.301	1.922	0.944	0.691	1.572	0.164	0.262	0.036	0.000	0.055	7.057	6.947	5.646	3.724	2.780	2.089
1977	0.000	0.028	3.527	1.080	0.523	0.279	0.727	0.051	0.066	0.000	0.020	6.301	6.301	6.273	2.746	1.666	1.143
1978	3.312	0.376	0.187	5.530	0.969	0.778	0.144	0.713	0.051	0.142	0.109	12.312	9.000	8.624	8.436	2.906	1.938
1979	0.109	0.435	1.359	0.298	1.913	0.541	0.234	0.087	0.145	0.012	0.022	5.156	5.047	4.611	3.253	2.955	1.042
1980	0.105	0.039	2.265	2.688	0.209	1.482	0.597	0.192	0.031	0.030	0.111	7.749	7.644	7.605	5.340	2.652	2.443
1981	0.301	2.303	1.916	2.779	1.667	0.100	0.870	0.269	0.144	0.000	0.085	10.435	10.134	7.831	5.914	3.135	1.468
1982[e]	0.148	0.488	3.395	1.406	1.295	1.039	0.016	0.298	0.064	0.016	0.035	8.200	8.053	7.564	4.169	2.763	1.468
1983	0.081	0.329	1.967	3.048	0.766	0.697	0.431	0.055	0.192	0.000	0.136	7.702	7.621	7.291	5.324	2.276	1.510
1984	0.000	0.402	0.462	0.797	1.161	0.446	0.424	0.223	0.000	0.156	0.008	4.079	4.079	3.677	3.215	2.418	1.257
1985	0.244	0.098	2.633	0.757	1.058	1.328	0.270	0.203	0.172	0.025	0.150	6.938	6.694	6.596	3.963	3.206	2.148
1986	0.092	0.871	0.423	1.824	0.360	0.545	0.633	0.063	0.119	0.095	0.015	5.040	4.948	4.077	3.654	1.830	1.470
1987	0.000	0.034	1.612	0.403	0.752	0.060	0.179	0.147	0.016	0.027	0.025	3.255	3.255	3.221	1.609	1.206	0.454
1988	0.180	0.700	0.684	3.115	0.413	0.645	0.045	0.020	0.052	0.000	0.007	5.861	5.681	4.981	4.297	1.182	0.769
1989	0.000	0.380	1.334	0.743	1.532	0.228	0.344	0.051	0.040	0.081	0.067	4.798	4.798	4.418	3.084	2.342	0.810
1990	0.041	0.194	0.926	1.707	0.653	0.896	0.125	0.139	0.013	0.016	0.027	4.736	4.695	4.501	3.575	1.868	1.215
1991	0.195	1.068	0.511	0.807	0.883	0.464	0.336	0.039	0.041	0.000	0.045	4.389	4.194	3.126	2.615	1.808	0.925
1992	0.000	0.123	1.255	0.470	0.163	0.270	0.144	0.161	0.020	0.037	0.028	2.671	2.671	2.548	1.293	0.823	0.660

[a] **During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents. Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).**

[b] **Spring surveys during 1981-1982 and 1989-1991 and autumn surveys during 1977-1981 and 1989-1991 were accomplished with the *R/V Delaware II*; in all other years, the surveys were accomplished using the *R/V Albatross IV*. Adjustments have been made to the *R/V Delaware II* catch per tow data to standardize these to *R/V Albatross IV* equivalents. Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991).**

[c] **Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a '36 Yankee' trawl. No adjustments have been made to the catch per tow data 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).**

Table 16. Continued

Year	Age Group											Totals					
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
								Autumn									
1963	0.019	0.719	0.778	0.920	0.897	0.354	0.326	0.175	0.103	0.014	0.069	4.374	4.356	3.636	2.858	1.938	1.041
1964	0.009	0.640	0.699	0.588	0.538	0.145	0.136	0.062	0.050	0.030	0.083	2.980	2.970	2.331	1.632	1.044	0.505
1965	0.173	1.299	0.998	0.707	0.484	0.167	0.179	0.112	0.081	0.023	0.023	4.248	4.075	2.775	1.777	1.070	0.587
1966	1.025	1.693	1.000	0.515	0.264	0.100	0.095	0.062	0.039	0.002	0.017	4.811	3.786	2.094	1.094	0.579	0.315
1967	0.072	7.596	1.334	0.523	0.406	0.133	0.133	0.055	0.051	0.012	0.070	10.383	10.312	2.716	1.382	0.860	0.454
1968	0.070	0.314	1.611	0.783	0.271	0.073	0.067	0.027	0.023	0.008	0.048	3.296	3.226	2.913	1.301	0.518	0.246
1969	0.000	0.343	0.622	0.626	0.331	0.094	0.061	0.019	0.023	0.022	0.059	2.200	2.200	1.856	1.234	0.608	0.278
1970	0.413	1.688	1.353	0.524	0.694	0.153	0.000	0.033	0.055	0.055	0.098	5.065	4.652	2.964	1.611	1.087	0.393
1971	0.399	0.602	0.632	0.390	0.301	0.476	0.183	0.042	0.089	0.000	0.075	3.189	2.789	2.187	1.555	1.165	0.864
1972	0.947	7.443	1.295	1.771	0.399	0.243	0.571	0.109	0.204	0.022	0.083	13.087	12.140	4.697	3.402	1.632	1.232
1973	0.203	1.749	6.070	1.182	2.012	0.211	0.226	0.175	0.062	0.139	0.251	12.280	12.078	10.329	4.259	3.076	1.064
1974	0.462	0.409	0.654	1.521	0.164	0.114	0.103	0.000	0.069	0.000	0.000	3.494	3.033	2.624	1.970	0.449	0.285
1975	2.377	0.994	0.421	0.624	1.685	0.112	0.156	0.000	0.000	0.000	0.037	6.407	4.029	3.036	2.615	1.991	0.306
1976	0.000	6.148	2.072	0.763	0.278	0.739	0.055	0.270	0.039	0.053	0.020	10.436	10.436	4.288	2.217	1.454	1.176
1977	0.152	0.237	3.424	0.702	0.251	0.174	0.396	0.007	0.027	0.000	0.078	5.447	5.296	5.059	1.635	0.933	0.682
1978	0.396	1.855	0.255	4.180	0.964	0.335	0.165	0.344	0.051	0.030	0.014	8.587	8.192	6.337	6.082	1.902	0.938
1979	0.118	1.619	1.717	0.224	1.613	0.296	0.180	0.036	0.115	0.007	0.022	5.948	5.829	4.210	2.493	2.269	0.656
1980	0.280	0.818	0.564	0.774	0.076	0.251	0.053	0.067	0.025	0.000	0.000	2.908	2.629	1.810	1.246	0.472	0.396
1981	0.261	3.525	2.250	1.559	0.589	0.054	0.579	0.057	0.064	0.018	0.083	9.040	8.778	5.254	3.003	1.444	0.855
1982	0.320	0.875	2.094	0.220	0.069	0.097	0.000	0.016	0.000	0.000	0.022	3.711	3.391	2.516	0.423	0.203	0.134
1983	1.031	0.647	1.022	0.796	0.055	0.047	0.003	0.000	0.012	0.000	0.023	3.636	2.605	1.958	0.936	0.140	0.086
1984	0.186	2.496	0.101	0.886	0.870	0.017	0.062	0.039	0.006	0.039	0.044	4.747	4.561	2.065	1.964	1.078	0.207
1985	1.084	0.220	0.803	0.103	0.115	0.101	0.000	0.000	0.004	0.000	0.000	2.430	1.346	1.126	0.323	0.220	0.105
1986	0.096	2.280	0.153	0.382	0.010	0.061	0.090	0.016	0.000	0.008	0.028	3.124	3.028	0.748	0.595	0.213	0.203
1987	0.204	0.414	1.353	0.112	0.195	0.028	0.012	0.000	0.000	0.007	0.000	2.325	2.121	1.707	0.354	0.242	0.047
1988	0.549	0.903	0.433	0.909	0.091	0.178	0.000	0.011	0.039	0.000	0.000	3.113	2.564	1.661	1.228	0.319	0.228
1989	0.262	2.738	1.030	0.183	0.499	0.055	0.008	0.004	0.000	0.000	0.000	4.780	4.518	1.780	0.750	0.566	0.067
1990[6]	0.156	0.362	1.534	1.164	0.209	0.145	0.012	0.013	0.000	0.000	0.022	3.617	3.460	3.098	1.564	0.401	0.192
1991	0.040	0.415	0.168	0.277	0.028	0.029	0.000	0.000	0.000	0.000	0.000	0.957	0.917	0.502	0.334	0.057	0.029
1992												1.870					

[6] **Excludes unusually high catch of 111 cod (504 kg) at Station 205 (Strata tow 23-4).**

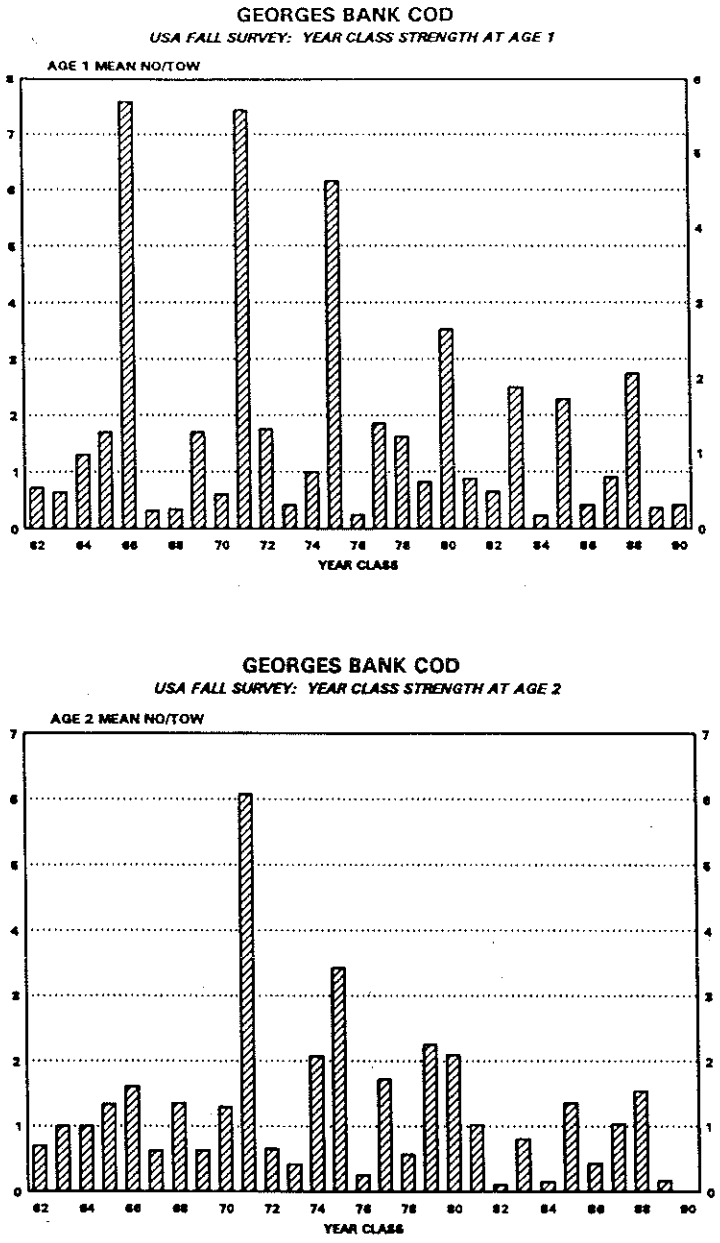

Figure 5. Relative year class strength of Georges Bank cod at age 1 and at age 2 based on standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1963-1991.

coefficient of variation (CV) on age 10 (56.45) was also unrealistically high.

The second formulation was the same as above except that a tri-cubic annual downweighting and an iterative reweighting of the indices [using the inverse of the partial variance from the previous calibration] were applied. The results were very similar to the base run, with a slight reduction in the F at age 9 (2.9) and the CV for age 10 (37.09).

The third and fourth analyses were formulated to duplicate the 1991 assessment results.

Table 17. Estimates of instantaneous total mortality (Z) and fishing mortality (F)[1] for Georges Bank cod stock for seven time periods, 1964-1991, derived from NEFSC offshore spring and autumn bottom trawl survey data[2]

Time Period	Spring		Autumn		Geometric Mean	
	Z	F	Z	F	Z	F
1964-67	-	-	0.73	0.53	0.73	0.53
1968-72	0.34	0.14	0.35	0.15	0.34	0.14
1973-76	0.70	0.50	0.56	0.36	0.63	0.43
1977-81	0.47	0.27	0.67	0.47	0.56	0.36
1982-84	0.42	0.22	1.12	0.92	0.68	0.48
1985-87	0.84	0.64	1.45	1.25	1.10	0.90
1988-91	0.69	0.49	1.07	0.87	0.86	0.66

[1] **Instantaneous natural mortality (M) assumed to be 0.20.**

[2] **Estimates derived from:**

Georges Bank spring:
ln (Σage 4+ for year i to j/Σage 5+ for years i+1 to j+1).

Georges Bank autumn:
ln(Σ age 3+ for years i-1 to j-1/Σage 4+ for years i to j).

Stock sizes were estimated in 1992 for ages 1-6, and the F on ages 6-10 in 1991 was derived as an unweighted mean of the F's for ages 4 and 5. The estimated F's for age 4 (1.41) and for age 5 (1.35) were very high and, therefore, the mean F applied to ages 6-10 (1.38) was also unreasonably high. The CVs on ages 1 to 6 ranged from 0.31 to 0.43, and were within acceptable limits. When the combined weighting was applied as above, the F on age 4 decreased to 1.07; otherwise, results were similar to the unweighted 1-6 formulation.

The fifth and sixth formulations employed Commonwealth of Massachusetts inshore research vessel survey indices (ages 1, 2, and 3 in the spring surveys; ages 1 and 2 in the autumn surveys (Table 19), in addition to the NEFSC and commercial CPUE indices. Otherwise the formulations were identical to the third and fourth runs. The Massachusetts survey indices did not perform very well; three of the five indices had high partial variances. The estimate of F for age 4 was reduced to 1.02, but remained high on age 5 (1.36) and the CVs on ages 1, 5, and 6 increased. When the combined weighting was applied as above, the estimates of F declined sharply on age 4 (< 0.10, unreasonably low) while the F on age 5 declined to 0.93. However, the CV on the age 6 stock size estimate in 1992 (the age 5 F in 1991) was considered unacceptable.

Several other formulations (not summarized in Table 18) were evaluated including:

Table 18. Parameter estimates (with associated statistics) and estimates of terminal F from trial ADAPT calibrations for Georges Bank cod

RUN 1 [Baseline Run]: Unweighted(1-10), no Commonwealth of Massachusetts trawl survey indices

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	CV	F in 1991
N 1	3.34704E3	1.55093E3	2.15808E0	0.46	1 ■ 0.0039
N 2	1.20128E4	3.94817E3	3.04262E0	0.33	2 ■ 0.3316
N 3	3.50944E3	1.05394E3	3.32982E0	0.30	3 ■ 0.6008
N 4	3.56292E3	1.19346E3	2.98538E0	0.33	4 ■ 1.1910
N 5	1.29628E3	5.17328E2	2.50573E0	0.40	5 ■ 1.0151
N 6	7.49764E2	2.88725E2	2.59680E0	0.39	6 ■ 0.5346
N 7	1.39301E3	6.61404E2	2.10614E0	0.47	7 ■ 0.4213
N 8	2.17621E2	1.32127E2	1.64706E0	0.61	8 ■ 0.0945
N 9	6.38947E2	3.37598E2	1.89263E0	0.53	9 ■ 3.0717
N10	1.01126E0	5.70896E1	1.77136E-2	56.45	10 ■ 3.0717

RUN 2: Weighted (1-10), no Commonwealth of Massachusetts trawl survey indices

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	CV	F in 1991
N 1	2.84290E3	1.38853E3	2.04741E0	0.49	1 ■ 0.0043
N 2	1.08419E4	2.49608E3	4.34355E0	0.23	2 ■ 0.3261
N 3	3.57903E3	6.25375E2	5.72302E0	0.17	3 ■ 0.6387
N 4	3.28208E3	6.52609E2	5.02916E0	0.20	4 ■ 0.9688
N 5	1.81590E3	4.60846E2	3.94036E0	0.25	5 ■ 1.0791
N 6	6.79320E2	2.15340E2	3.15463E0	0.32	6 ■ 0.5629
N 7	1.30251E3	5.00630E2	2.60174E0	0.38	7 ■ 0.6188
N 8	1.33091E2	8.62647E1	1.54282E0	0.65	8 ■ 0.1038
N 9	5.79229E2	2.49776E2	2.31899E0	0.43	9 ■ 2.8798
N10	1.23793E0	4.59098E1	2.69644E-2	37.09	10 ■ 2.8798

RUN 3: Unweighted (1-6), no Commonwealth of Massachusetts trawl survey indices

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	CV	
N 1	4.40501E3	1.88868E3	2.33233E0	0.43	1 ■ 0.0032
N 2	1.46094E4	4.43995E3	3.29043E0	0.30	2 ■ 0.3050
N 3	3.86860E3	1.05953E3	3.65125E0	0.27	3 ■ 0.6334
N 4	3.31967E3	1.04182E3	3.18640E0	0.31	4 ■ 1.4132
N 5	9.54833E2	3.58700E2	2.66193E0	0.38	5 ■ 1.3551
N 6	4.58530E2	1.72378E2	2.66002E0	0.38	6 ■ 1.3842
					7 ■ 1.3842
					8 ■ 1.3842
					9 ■ 1.3842
					10 ■ 1.3842

RUN 4: Weighted (1-6), no Commonwealth of Massachusetts trawl survey indices

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	CV	F in 1991
N 1	3.30962E3	1.64840E3	2.00778E0	0.50	1 ■ 0.0038
N 2	1.22154E4	2.79172E3	4.37558E0	0.23	2 ■ 0.3184
N 3	3.68037E3	6.25190E2	5.88681E0	0.17	3 ■ 0.6861
N 4	2.97625E3	5.62424E2	5.29182E0	0.19	4 ■ 1.0761
N 5	1.53563E3	3.64835E2	4.20912E0	0.24	5 ■ 1.3324
N 6	4.72850E2	1.39578E2	3.38773E0	0.30	6 ■ 1.2042
					7 ■ 1.2042
					8 ■ 1.2042
					9 ■ 1.2042
					10 ■ 1.2042

RUN 5: Unweighted (1-6), WITH Commonwealth of Massachusetts trawl survey indicies

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	CV	
N 1	1.70100E4	8.81254E3	1.93020E0	0.52	1 ■ 0.0047
N 2	1.00002E4	3.67547E3	2.72078E0	0.37	2 ■ 0.3145
N 3	3.73436E3	1.25103E3	2.98504E0	0.34	3 ■ 0.5895
N 4	3.65369E3	1.46182E3	2.49941E0	0.40	4 ■ 1.0150
N 5	1.68735E3	8.48690E2	1.98818E0	0.50	5 ■ 1.3550
N 6	4.58578E2	2.50847E2	1.82812E0	0.55	6 ■ 1.1850
					7 ■ 1.1850
					8 ■ 1.1850
					9 ■ 1.1850
					10 ■ 1.1850

RUN 6: Weighted (1-6), WITH Commonwealth of Massachusetts trawl survey indices

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	CV	
N 1	3.67264E5	1.99725E5	1.83885E0	0.54	1 ■ 0.0061
N 2	7.64601E3	2.91795E3	2.62034E0	0.38	2 ■ 0.2453
N 3	4.96334E3	1.64663E3	3.01424E0	0.33	3 ■ 0.4008
N 4	5.95253E3	2.41126E3	2.46864E0	0.41	4 ■ 0.0576
N 5	5.00640E4	1.49552E4	3.34760E0	0.305	5 ■ 0.9316
N 6	8.57446E2	8.88379E2	9.65180E-1	1.04	6 ■ 0.4946
					7 ■ 0.4946
					8 ■ 0.4946
					9 ■ 0.4946
					10 ■ 0.4946

Table 19. Stratified mean catch per tow in numbers and weight (kg) of Atlantic cod in Commonwealth of Massachusetts inshore spring and autumn bottom trawl surveys in territorial waters adjacent to the Georges Bank area (Mass. Regions 1-3)[1], 1978 - 1992.

	Age Group											Totals				Mean Weight (kg) Per Tow
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	
							Spring									
1978	42.589	1.403	0.054	0.034	0.019	0.000	0.000	0.000	0.000	0.000	0.000	44.099	1.510	0.107	0.053	0.41
1979	5.286	7.121	0.124	0.014	0.020	0.002	0.000	0.000	0.000	0.000	0.000	12.567	7.281	0.160	0.036	0.97
1980	5.092	3.965	1.973	0.045	0.002	0.003	0.019	0.000	0.000	0.000	0.000	11.099	6.007	2.042	0.069	1.90
1981	31.453	0.127	0.047	0.114	0.011	0.000	0.000	0.000	0.011	0.000	0.000	31.763	0.310	0.183	0.136	0.59
1982	13.303	0.628	0.191	0.234	0.110	0.062	0.002	0.021	0.002	0.000	0.019	14.572	1.269	0.641	0.450	2.17
1983	8.814	4.422	0.533	0.206	0.042	0.058	0.000	0.000	0.000	0.000	0.000	14.075	5.261	0.839	0.306	1.84
1984	1.314	1.016	0.096	0.076	0.033	0.000	0.000	0.000	0.000	0.000	0.000	2.535	1.221	0.205	0.109	0.47
1985	4.676	0.172	0.127	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000	5.013	0.337	0.165	0.038	0.25
1986	6.232	1.427	0.258	0.078	0.011	0.011	0.011	0.000	0.000	0.000	0.000	8.028	1.796	0.369	0.111	0.88
1987	0.639	2.134	4.417	0.061	0.017	0.000	0.039	0.000	0.000	0.000	0.000	7.307	6.668	4.534	0.117	3.66
1988	8.646	5.679	0.876	0.447	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.648	7.002	1.323	0.447	1.46
1989	0.677	1.105	0.439	0.151	0.049	0.000	0.000	0.000	0.000	0.000	0.000	2.421	1.744	0.639	0.200	0.74
1990	9.060	0.060	0.130	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	9.270	0.210	0.150	0.020	0.22
1991	0.420	0.250	0.090	0.050	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.840	0.420	0.170	0.080	0.18
1992	Age Data Not Yet Available											2.438				0.26
							Autumn									
1978	7.318	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.318	0.000	0.000	0.000	0.11
1979	0.156	0.230	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.388	0.232	0.002	0.000	0.09
1980	0.475	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.520	0.045	0.000	0.000	0.03
1981	1.131	0.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.246	0.115	0.000	0.000	0.08
1982	0.061	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.080	0.019	0.000	0.000	0.01
1983	0.165	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.165	0.000	0.000	0.000	<0.01
1984	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.019	0.000	0.000	0.02
1985	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	0.019	0.000	0.000	0.01
1986	0.035	0.115	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.169	0.134	0.019	0.000	0.05
1987	9.463	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.488	0.025	0.000	0.000	0.01
1988	0.100	1.705	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.805	1.705	0.000	0.000	0.17
1989	0.314	1.763	0.153	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.230	1.916	0.153	0.000	0.57
1990	0.110	0.110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.220	0.110	0.000	0.000	0.02
1991	3.830	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.830	0.000	0.000	0.000	0.03
1992																

[1] **Massachusetts inshore survey sampling strata 11-21.**

Table 20. Estimates of instantaneous fishing mortality (F), beginning year stock sizes (millions of fish), and mean stock biomass (mt) for Georges Bank cod estimated from virtual population analysis (VPA) calibrated using the ADAPT procedure, 1978-1991

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Fishing Mortality														
1	0.0001	0.0016	0.0049	0.0007	0.0212	0.0125	0.0033	0.0176	0.0041	0.0018	0.0005	0.0000	0.0009	0.0031
2	0.1073	0.1019	0.2449	0.2439	0.3543	0.4131	0.2062	0.3846	0.2412	0.2730	0.1440	0.1376	0.4244	0.2856
3	0.4087	0.3811	0.4845	0.4761	0.5149	0.6129	0.6912	0.7396	0.5237	0.4359	0.5304	0.4314	0.5714	0.5512
4	0.3861	0.4903	0.3781	0.3885	0.6769	0.7514	0.5576	0.6659	0.5734	0.4941	0.6545	0.5844	0.5523	0.9481
5	0.3839	0.3609	0.4562	0.3062	0.6361	0.5931	0.6309	0.7239	0.5201	0.4020	0.8006	0.4608	0.7517	1.1961
6	0.1379	0.3789	0.6372	0.5624	0.7408	0.5470	0.6610	0.7481	0.5650	0.5752	0.7521	0.7799	0.6824	1.0721
7	0.3091	0.1122	0.7913	0.5479	0.5822	0.6037	0.7441	0.6605	0.3384	0.5099	0.9333	0.6168	1.0594	1.0721
8	1.4851	0.3922	0.1789	0.5229	0.6073	0.4109	0.6328	0.9113	0.4740	0.4403	0.8984	0.6998	0.6113	1.0721
9[1]	0.3606	0.4385	0.4897	0.4426	0.6623	0.6522	0.6007	0.7230	0.5459	0.4957	0.7684	0.6002	0.6720	1.0721
10+[2]	0.3606	0.4385	0.4897	0.4426	0.6623	0.6522	0.6007	0.7230	0.5459	0.4957	0.7684	0.6002	0.6720	1.0721
4+	0.3043[3]	0.3622	0.4886	0.4618	0.6508	0.5930	0.6379	0.7388	0.5028	0.4862	0.8012	0.6236	0.7215	1.0721

Stock Numbers (Jan 1) in thousands

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	27710.1	23507.3	20090.9	41376.4	17461.0	9589.3	27257.7	8499.0	42391.2	15905.3	21929.0
2	4267.7	22685.3	19215.4	16368.5	33851.7	13996.4	7753.3	22243.4	6837.2	34565.8	12998.7
3	25524.0	3138.5	16773.4	12314.7	10501.4	19447.0	7581.1	5165.3	12396.9	4398.0	21538.2
4	7946.0	13886.6	1755.2	8459.5	6263.1	5137.7	8626.2	3109.6	2018.4	6011.9	2328.6
5	2877.5	4421.8	6962.8	984.6	4696.5	2606.0	1984.3	4044.0	1308.1	931.4	3003.0
6	1124.2	1604.9	2523.6	3612.3	593.5	2035.5	1179.0	864.4	1605.3	636.7	510.1
7	1434.0	801.9	899.5	1092.5	1685.3	231.7	964.4	498.4	334.9	747.0	293.3
8	67.2	861.9	586.8	333.8	517.2	770.9	103.7	375.2	210.8	195.5	367.3
9	146.0	12.5	476.7	401.7	162.0	230.7	418.5	45.1	123.5	107.4	103.0
10+	54.3	148.1	28.3	189.9	187.0	148.1	292.7	205.5	75.4	67.2	95.5
1+	71150.8	71068.5	69312.6	85134.0	75918.8	54193.2	56160.8	45049.9	67301.7	63566.3	63166.7

	1989	1990	1991	1992
1	19289.3	8294.0	18309.1	3274.6
2	17944.9	15792.7	6784.2	14943.2
3	9215.5	12802.7	8458.3	4174.6
4	10375.4	4901.1	5919.8	3990.7
5	990.8	4735.1	2309.7	1878.0
6	1104.1	511.7	1828.2	571.8
7	196.9	414.4	211.7	512.3
8	94.4	87.0	117.6	59.3
9	122.4	38.4	38.6	33.0
10+	43.6	84.7	37.9	21.5
1+	59377.3	47661.9	44015.3	29458.8

[1] **For all years prior to the terminal year of 1991, back-calculated stock sizes for ages 4-9 were used to estimate total mortality (Z) for age 9.**
[2] **F on age 10+ is assumed to be equivalent to F on age 9.**
[3] **Arithmetic average of ages 4-7 which removes the influence of the anomalously high F on age 8 in 1978.**

1) 9+ group vs. 10+;
2) estimating ages 1-7;
3) deleting the 1991 NEFSC autumn survey;
4) selectively deleting survey values which showed relatively high residuals.

Each of the runs showed similar results with high F's on ages 4 and 5 in 1991 and unacceptable CVs on several of the age group stock size estimates in 1992. It should be noted that Hunt and Buzeta (1992), in conducting the 1992 Canadian assessment of Georges Bank cod (*i.e*, cod in Unit Areas 5Zj and 5Zm), encountered similar VPA calibration problems using the same set of U.S. survey indices. They noted that the high F estimates appeared to be related to the adjustments made in standardizing the NEFSC survey data (for the survey door and vessel effects) which tended to accelerate the apparent rate of decline of cohorts over time by reducing the 1984-1991 indices relative to those in previous years. Based on effort comparisons, the Canadian scientists elected to reduce the high 1991 F estimates to coincide with the 1990 values.

The final ADAPT calibration was performed with the NEFSC spring and autumn abundance indices for ages 1 to 6 and U.S. commercial LPUE

Table 20. Continued

Spawning Stock Biomass (mt) at the Beginning of the Spawning Season (March 1)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	912.4	1103.8	849.7	1959.5	1199.2	900.4	3108.3	757.8	6933.9	1774.8	2673.1
2	1410.0	7537.9	6911.1	5778.0	16130.9	6340.9	4290.9	11588.5	4702.3	23980.9	8252.2
3	33841.6	3728.1	22413.4	15922.7	15626.3	26041.7	10489.6	6851.1	18625.8	6905.4	32435.1
4	20217.4	38250.5	4296.1	21373.8	15782.5	12626.3	21629.8	8058.8	4804.5	16797.8	5857.4
5	8797.7	16582.8	30435.3	3957.1	17466.4	9627.2	7084.7	14874.6	5414.3	3884.9	12086.5
6	4881.5	8129.6	12538.0	20315.5	2955.8	10512.6	5642.6	4213.4	8546.7	3681.2	2704.9
7	8213.7	5548.9	5917.4	7293.0	12164.3	1459.0	6218.3	3152.2	2314.8	5323.5	1999.1
8	366.9	6809.3	5033.0	2695.3	4161.9	6832.5	809.7	2976.8	1691.4	1660.0	2891.1
9	1330.5	111.6	3962.5	4096.0	1560.2	2109.6	3948.5	415.3	1242.7	1019.8	926.2
10+	653.3	1681.0	388.0	3167.0	2708.9	1869.9	3933.2	2377.3	938.9	897.5	1243.0
1+	80625.0	89483.5	92744.6	86557.9	89756.5	78320.1	67155.7	55266.0	55215.3	65925.9	71068.5

	1989	1990	1991
1	2499.9	1095.6	4344.7
2	12238.9	10232.2	4656.1
3	14018.0	20440.9	13539.5
4	26612.8	11977.4	13901.8
5	3862.7	17356.3	7500.7
6	5638.2	2582.0	7939.0
7	1270.2	2527.5	1173.2
8	788.2	711.0	897.4
9	1156.6	385.5	317.5
10+	652.5	1064.5	471.5
1+	68737.8	68372.9	54741.3

The above SSB by age (a) and year (y) are calculated following the algorithm used int he NEFSC projection program, *i.e.*:

$$SSB(a,y) = W(a,y) \times P(a,y) \times (N(a,y) \times \exp[-Z(a,y)]$$

where $Z(a,y)$ = $0.1667 \times F(a,y)$
$N(a,y)$ = Jan 1 stock size estimates (males and females)
$P(a,y)$ = proportion mature (generally females)
$W(a,y)$ = weight at age at the beginning of the spawning season

The W(a,y) are assumed to be the same as the Jan 1 weights at age and are calculated as geometric means in ADAPT from the mid-year weight at age estimates (from the catch) of the cohort in successive years.

Percent Mature

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	7	7	7	7	13	13	13	13	23	23	23	23	23	23
2	34	34	34	34	47	47	47	47	64	64	64	64	64	64
3	78	78	78	78	84	84	84	84	91	91	91	91	91	91
4	96	96	96	96	97	97	97	97	98	98	98	98	98	98
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	100	100	100	100	100
10+	100	100	100	100	100	100	100	100	100	100	100	100	100	100

indices for ages 3 to 6 (Appendix 1). Due to the inordinate effect of high residuals in the converged period of the VPA on the stock size estimates in the terminal year, linear time-tapered downweighting was applied with zero weight given to all years prior to 1982. In addition, all indices were weighted according to the inverse of their variance. Stock sizes in 1992 were estimated for ages 1 to 6, providing estimates of F in 1991 for ages 1 to 5. A flat-topped partial recruitment pattern was used, with full F on ages 4 and older (as indicated by a separable VPA). F's on ages 6 to 9 in 1991 were taken as the mean of F on ages 4 and 5 (the only fully recruited ages which were estimated directly). In years prior to the terminal year of 1991, F on the oldest true age (age 9) was determined from estimates of Z for ages 4 to 8. F for the plus group (age 10+) in each year was set equal to the estimated F on age 9. Spawning stock biomass (SSB) was calculated at spawning time [March 1] by applying maturity ogives for 1978-1981, 1982-1985, and 1986-1991, derived from O'Brien (1990).

Full results from the final VPA calibration are presented in Appendix 1, and estimates of F, stock size, and spawning stock biomass are given in Table 20. The final calibration exhibited very low correlations (<0.12) among estimates of slopes (q), and moderately low correlations (<0.30) between stock sizes and q's (Appendix 1: Page 49).

Average fishing mortality (ages 4 to 8, unweighted) in 1991 was estimated at 1.07 (Table 20, Figure 6), sharply higher than in 1989 (0.64) and 1990 (0.73). This 47% increase in F is inconsistent with the 3% increase in standardized fishing effort indicated by the GLM (Table 14). However, it is possible that changes occurred within the fishery that were not captured

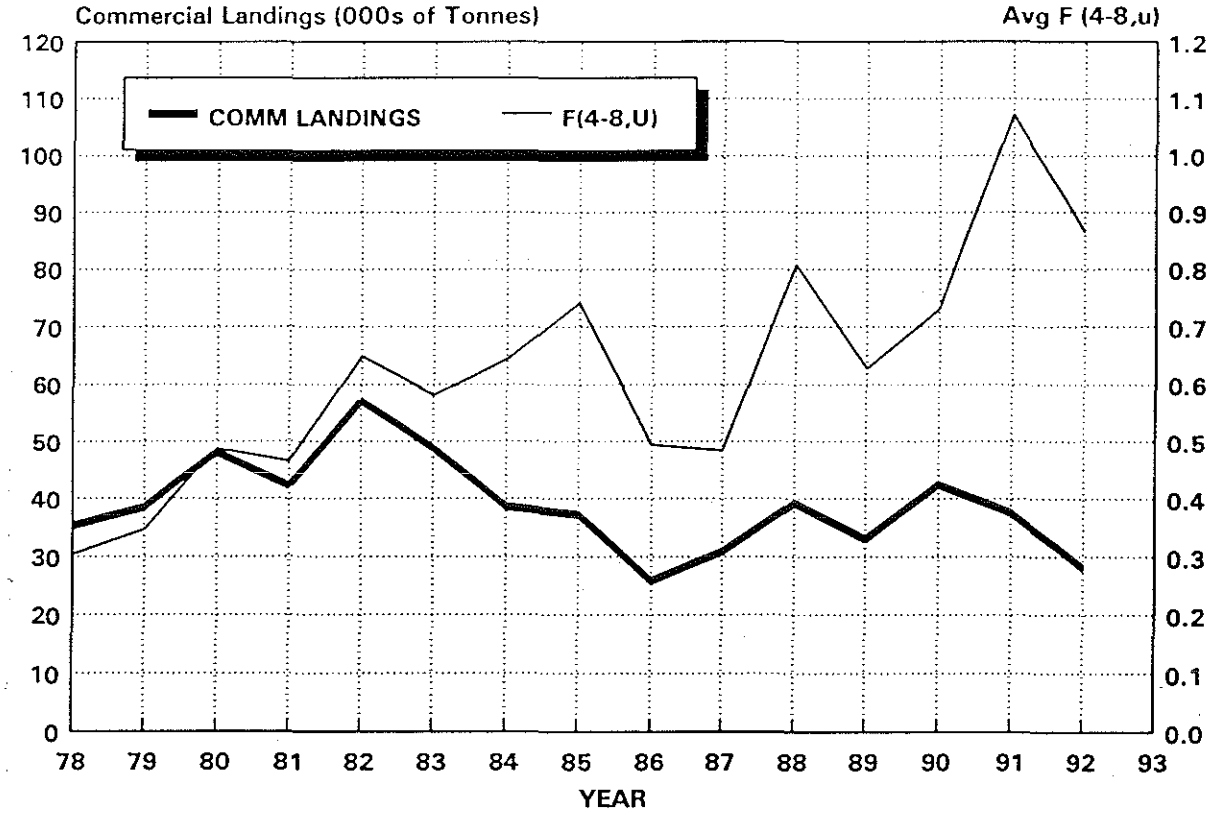

Figure 6. Trends in total commercial landings and fishing mortality for Georges Bank cod, 1978-1992.

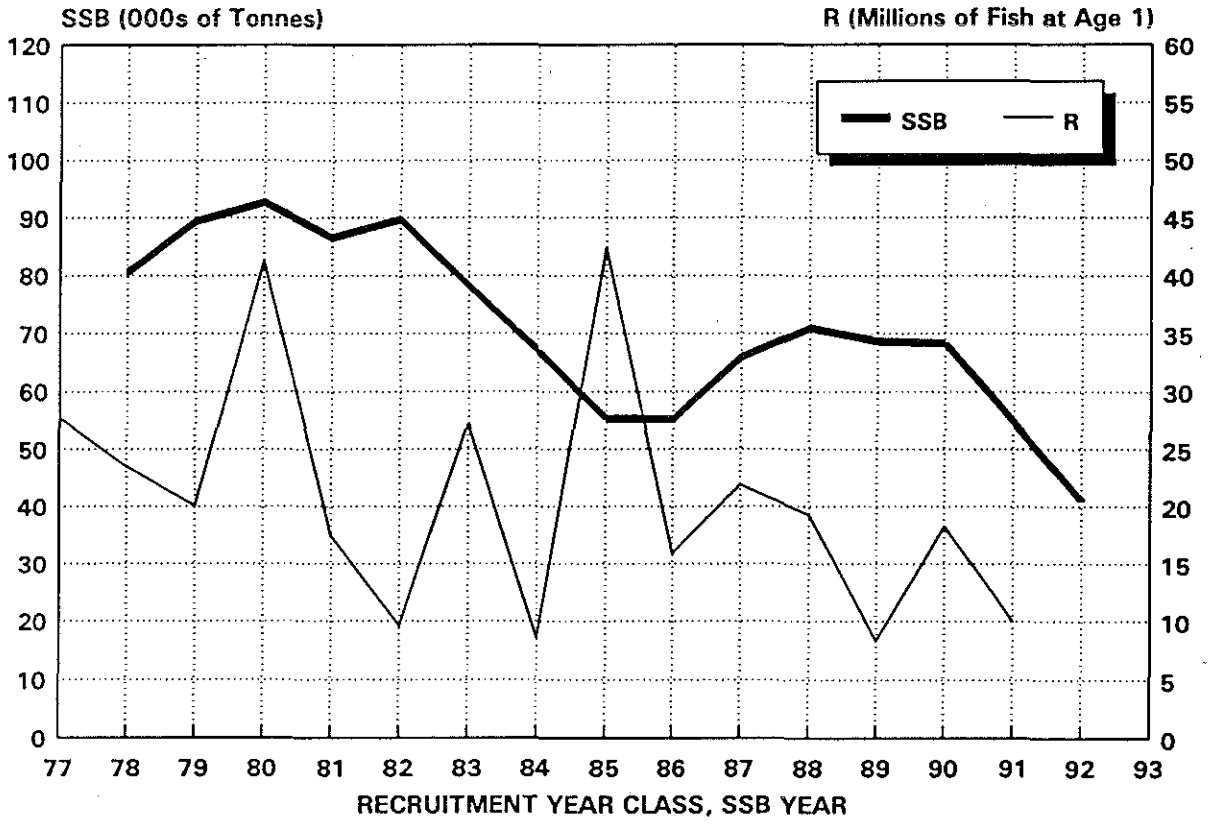

Figure 7. Trends in spawning stock biomass and recruitment for Georges Bank cod.

Table 21. Precision and bias of estimates of the age-specific stock size estimates (number of fish) on January 1, 1992 for Georges Bank cod. ADAPT estimate is from the final VPA run. Standard errors, coefficients of variation (CV), and bias estimates are derived from 200 bootstrap replications.

Age	ADAPT Estimate	Bootstrap Mean	Bootstrap Std Error	CV for ADAPT SOLN
1	3.275E3	3.960E3	2.696E3	0.82
2	1.494E4	1.584E4	4.656E3	0.31
3	4.175E3	4.286E3	8.271E2	0.20
4	3.991E3	4.054E3	9.879E2	0.25
5	1.878E3	1.926E3	5.492E2	0.29
6	5.718E2	6.104E2	1.988E2	0.35
7	5.123E2	5.203E2	1.152E2	0.22
8	5.993E1	6.026E1	1.334E1	0.22
9	3.296E1	3.348E1	7.412E0	0.22
10+	2.146E1	2.179E1	4.850E0	0.23

Age	Bias Estimate	Bias Std Error	Percent Boas	ADAPT Est Corrected for Bias	CV for Corrected Estimate
1	6.856E2	1.907E2	20.94	2.589E3	1.04
2	8.953E2	3.293E2	5.99	1.405E4	0.33
3	1.114E2	5.848E1	2.67	4.063E3	0.20
4	6.353E1	6.985E1	1.59	3.927E3	0.25
5	4.808E1	3.883E1	2.56	1.830E3	0.30
6	3.860E1	1.405E1	6.75	5.332E2	0.37
7	7.987E0	8.146E0	1.56	5.044E2	0.23
8	9.250E-1	9.433E-1	1.56	5.841E1	0.23
9	5.139E-1	5.241E-1	1.56	3.245E1	0.23
10+	3.381E-1	3.429E-1	1.58	2.112E1	0.23

by the standardization procedure and these may have contributed to the higher-than-expected F in 1991.

Spawning stock biomass, which had stabilized at about 70,000 mt during 1988-1990 due to strong recruitment from the 1983 and 1985 year classes (Figure 7), declined to 54,700 mt in 1991 and fell to a record low 41,000 mt in 1992. Recruitment of the 1988-1991 year classes has been below average (*i.e.*, below 21 million fish at age 1), and the 1989 and 1991 year classes appear to be among the poorest on record. The 1990 year class, which in the 1991 assessment (Serchuk *et al.* 1991; NEFSC 1992) had been estimated to be a strong one (28 million fish at age 1), is now estimated to be slightly below average (18 million fish at age 1).

The estimation uncertainty associated with the estimates of stock size and fishing mortality from the final VPA was evaluated using a bootstrap procedure (Efron 1982). Two hundred bootstrap iterations were performed to derive standard errors, coefficients of variation (CVs) and bias estimates for the age-specific stock sizes at the start of 1992 (Table 21), the catchability estimates (q) for each index of abundance used in calibrating the VPA (Table 22), and the age-specific F's in 1991 (Tables 23). As well, frequency distributions were generated of the 1991 fishing mortality and spawning stock biomass bootstrap estimates and cumulative probability curves produced (Figures 8 and 9).

The bootstrap results indicate that age-specific stock sizes in 1992 were generally well estimated for ages 2 and older (CVs ranging from 0.20 to 0.35). The age 1 stock size in 1992, however, was poorly estimated (CV = 0.82) (Table 21). Coefficients of variation on the catchability estimates of the indices of abundance used in the final ADAPT calibration ranged from 0.07 to 0.20 for the five commercial LPUE indices, and from 0.10 to 0.48 for the 12 NEFSC bottom trawl survey indices (Table 22). The widest variances on q from the survey indices were associated with the spring age 1 index (CV = 0.48) and the autumn age 5 index (CV = 0.42).

The fully recruited fishing mortality (ages 4+) in 1991 was reasonably well estimated (CV=

Table 22. Precision and bias of catchability estimates (q) for each index of abundance used in calibrating the final ADAPT run for Georges Bank cod. Standard errors, coefficients of variation (CV), and bias estimates are derived from 200 bootstrap replications. The q's have been re-scaled to original units.

Index	ADAPT Estimate	Bootstrap Mean	Bootstrap Standard Error	CV for ADAPT SOLN
RV SPR 1	2.214E-5	2.711E-5	1.065E-5	0.48
RV SPR 2	6.974E-5	7.278E-5	8.928E-6	0.13
RV SPR 3	1.139E-4	1.165E-4	1.094E-5	0.10
RV SPR 4	1.285E-4	1.411E-4	3.254E-5	0.25
RV SPR 5	1.932E-4	2.119E-4	4.071E-5	0.21
RV SPR 6	2.267E-4	2.426E-4	4.831E-5	0.21
RV FAL 1	1.594E-5	1.752E-5	4.271E-6	0.27
RV FAL 2	5.677E-5	6.410E-5	1.577E-5	0.28
RV FAL 3	6.540E-5	7.268E-5	1.967E-5	0.30
RV FAL 4	7.959E-5	9.374E-5	2.587E-5	0.32
RV FAL 5	5.348E-5	6.399E-5	2.259E-5	0.42
RV FAL 6	7.121E-5	7.763E-5	1.598E-5	0.22
CM CPE 2	5.606E-6	6.001E-6	1.102E-6	0.20
CM CPE 3	1.101E-5	1.130E-5	9.651E-7	0.09
CM CPE 4	1.195E-5	1.261E-5	1.462E-6	0.12
CM CPE 5	1.246E-5	1.318E-5	1.748E-6	0.14
CM CPE 6	1.313E-5	1.348E-5	9.479E-7	0.07

Index	Bias Estimate	Bias Standard Error	Percent Bias	ADAPT Estimate Corrected for Bias	CV for Corrected Estimate
RV SPR 1	4.974E-6	7.532E-7	22.46	1.717E-5	0.62
RV SPR 2	3.036E-6	6.313E-7	4.35	6.671E-5	0.13
RV SPR 3	2.613E-6	7.735E-7	2.29	1.112E-4	0.10
RV SPR 4	1.225E-5	2.301E-6	9.77	1.160E-4	0.28
RV SPR 5	1.874E-5	2.879E-6	9.70	1.744E-4	0.23
RV SPR 6	1.584E-5	3.416E-6	6.99	2.109E-4	0.23
RV FAL 1	1.579E-6	3.020E-7	9.91	1.436E-5	0.30
RV FAL 2	7.329E-6	1.115E-6	12.91	4.944E-5	0.32
RV FAL 3	7.277E-6	1.391E-6	11.13	5.813E-5	0.34
RV FAL 4	1.415E-5	1.829E-6	17.78	6.544E-5	0.40
RV FAL 5	1.051E-5	1.597E-6	19.66	4.297E-5	0.53
RV FAL 6	6.430E-6	1.130E-6	9.03	6.478E-5	0.25
CM CPE 2	3.947E-7	7.796E-8	7.04	5.212E-6	0.21
CM CPE 3	2.907E-7	6.824E-8	2.64	1.071E-5	0.09
CM CPE 4	6.620E-7	1.034E-7	5.54	1.129E-5	0.13
CM CPE 5	7.419E-7	1.236E-7	5.77	1.174E-5	0.15
CM CPE 6	3.547E-7	6.703E-8	2.70	1.277E-5	0.07

0.14), as were the age-specific F's for ages 1 to 5 (CVs from 0.17 to 0.33) (Table 23). The mean bootstrap estimate of the fully recruited F in 1991 (F_{1991} = 1.083) was slightly higher than the VPA point estimate (F_{1991} = 1.072). The distribution of the F_{1991} estimates obtained from the 200 bootstrap replications ranged between F=0.70 and F=1.60 (Figure 8). Based on the cumulative probability curve (Figure 8), there is an 80% probability that the 1991 F lies between 0.86 and 1.22. This implies that there is a 90% probability that the 1991 F was greater than 0.86 (*i.e.*, more than twice as high as the overfishing definition of $F_{20\%}$ = 0.35).

Fishing mortality estimates for 1990 (0.73) and 1992 (0.87) fall within the lower range of the 1991 bootstrap estimates of F. Therefore, given the amount of precision associated with the 1991 F estimate, there is about a 60% probability that the true F_{1991} was greater than the fishing mortality in adjacent years.

The bootstrap mean of spawning stock bio-

Table 23. Precision and bias estimates of the age-specific instantaneous fishing mortality rates (F) in 1991 for Georges Bank cod. ADAPT estimate is from the final VPA run. Standard errors, coefficients of variation (CV) and bias estimates are derived from 200 bootstrap replications. Ages 4+ represent the fully-recruited portion of the stock.

Age	ADAPT Estimate	Bootstrap Mean	Bootstrap Standard Error	CV for ADAPT SOLN
1	3.144E-3	3.235E-3	1.029E-3	0.33
2	2.856E-1	2.869E-1	4.777E-2	0.17
3	5.512E-1	5.666E-1	1.213E-1	0.22
4	9.481E-1	9.675E-1	1.829E-1	0.19
5	1.196E0	1.199E0	2.355E-1	0.20
6	1.072E0	1.083E0	1.466E-1	0.14
7	1.072E0	1.083E0	1.466E-1	0.14
8	1.072E0	1.083E0	1.466E-1	0.14
9	1.072E0	1.083E0	1.466E-1	0.14
10+	1.072E0	1.083E0	1.466E-1	0.14
4+	1.072E0	1.083E0	1.466E-1	0.14

Index	Bias Estimate	Bias Standard Error	Percent Bias	ADAPT Estimate Corrected for Bias	CV for Corrected Estimate
1	9.102E-5	7.273E-5	2.90	3.053E-3	0.34
2	1.329E-3	3.378E-3	0.47	2.843E-1	0.17
3	1.546E-2	8.575E-3	2.80	5.357E-1	0.23
4	1.935E-2	1.294E-2	2.04	9.288E-1	0.20
5	3.049E-3	1.665E-2	0.25	1.193E0	0.20
6	1.120E-2	1.036E-2	1.04	1.061E0	0.14
7	1.120E-2	1.036E-2	1.04	1.061E0	0.14
8	1.120E-2	1.036E-2	1.04	1.061E0	0.14
9	1.120E-2	1.036E-2	1.04	1.061E0	0.14
10+	1.120E-2	1.036E-2	1.04	1.061E0	0.14
4+	1.120E-2	1.036E-2	1.04	1.061E0	0.14

mass in 1991 (55,600 mt) was rather precise (CV = 0.09) and slightly higher than the VPA point estimate (54,700 mt). The range of the 200 individual bootstrap replicates of SSB in 1991 ranged between 45,000 and 72,500 mt (Figure 9). Based on the cumulative probability curve (Figure 9), there is an 80% probability that the 1991 SSB was between 48,000 and 61,000 mt.

YIELD AND SPAWNING STOCK BIOMASS PER RECRUIT

Yield-per-recruit (YPR), total stock biomass per recruit, and spawning stock biomass per recruit (SSB/R) analyses were performed using the Thompson and Bell (1934) method. To obtain the exploitation pattern for these analyses, a separable VPA analysis was run (Table 24). Fishing mortality on age 4 (the reference age for the terminal F) was set at 0.712 and a terminal S value of 1.0 was used for the oldest true age group (age 9). A flat-topped exploitation pattern was evident for age groups 4 and older (S values near 1.0). Accordingly, in the YPR and SSB/R analyses, age groups 4 and older were considered to be fully recruited (S = 1.0).

Mean weights at age used in the YPR analyses were computed as the arithmetic average of landings mean weights at age (Table 7) over the 1989-1991 period. Mean weights at age for use in the SSB/R analyses were computed as the arithmetic average of stock mean weights at age (Table 9) over the period 1989-1991. The maturation ogive was taken from O'Brien *et al.* (in press). To obtain the exploitation pattern for the YPR and SSB/R analyses, geometric mean F's at age were computed for the 1986-1990 period from the final VPA. A smoothed exploitation pattern was then obtained by dividing the mean F's at age by the mean unweighted F for ages 4 to

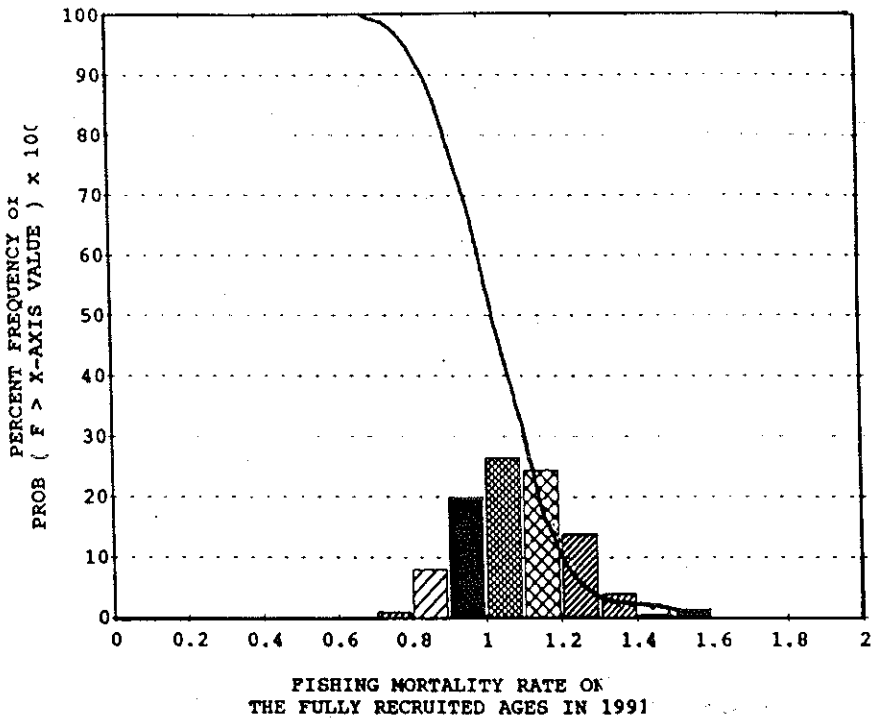

Figure 8. Precision of the estimates of the instantaneous rate of fishing mortality (F) on the fully recruited ages (ages 4+) in 1991 for Georges Bank cod. The vertical bars display both the range of the estimator and the probability of individual values within the range. The solid line gives the probability that F is greater than any selected value on the X-axis. The precision estimates were derived from 200 bootstrap replications.

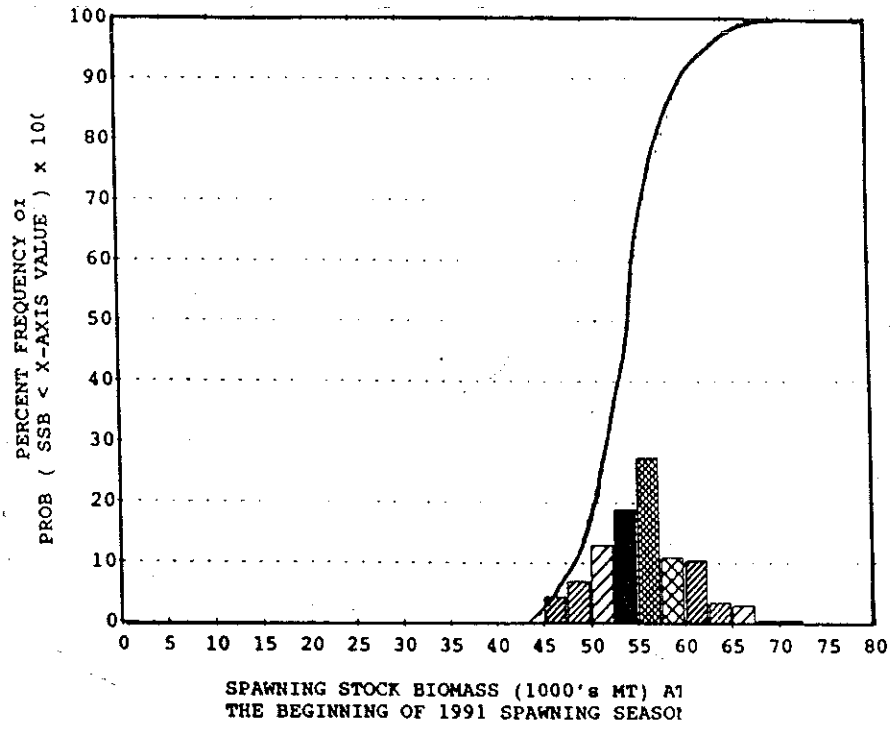

Figure 9. Precision of the estimates of spawning stock biomass (SSB) at the beginning of the 1991 spawning season (March 1) for Georges Bank cod. The vertical bars display both the range of the estimator and the probability of individual values within the range. The solid line gives the probability that SSB is less than any selected value on the X-axis. The precision estimates were derived from 200 bootstrap replications.

Table 24. Matrix of residuals and exploitation pattern from separable VPA for Georges Bank cod

ATLANTIC COD - GEORGES BANK - TERMINAL YEAR: 1991

Separable analysis
from 1978 to 1991 on ages 1 to 9
with Terminal F of 0.712 on age 4 and Terminal S of 1.000

Matrix of Residuals

Ages	Years		
	1978/79	1979/80	1980/81
1/2	-2.297	0.222	0.899
2/3	-0.490	-0.444	0.044
3/4	-0.035	0.377	0.129
4/5	0.061	0.457	-0.060
5/6	0.175	-0.019	-0.162
6/7	-0.077	-0.297	0.089
7/8	-0.295	-0.442	0.435
8/9	1.851	0.091	-1.255
	0.000	0.000	0.000
WTS	1.000	1.000	1.000

Ages	Years										
	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	WTS
1/2	-0.890	1.903	2.048	0.289	1.841	0.598	0.770	-0.995	-3.709	-0.680	0.000 0.100
2/3	0.391	0.179	0.368	-0.382	0.088	0.097	0.470	-0.616	-0.430	0.725	0.000 0.391
3/4	0.106	-0.450	0.096	0.229	-0.090	0.048	0.007	-0.251	0.016	-0.182	0.000 0.794
4/5	-0.180	-0.007	0.202	-0.201	-0.252	0.246	-0.053	0.124	0.103	-0.439	0.000 0.711
5/6	-0.423	0.121	-0.005	0.086	-0.037	0.000	-0.118	0.184	0.013	0.184	0.000 1.000
6/7	0.297	0.042	-0.405	0.024	0.195	-0.001	0.003	0.048	0.241	-0.158	0.000 0.844
7/8	0.242	0.022	-0.151	-0.011	-0.241	-0.514	-0.122	0.286	0.280	0.509	0.000 0.511
8/9	0.121	-0.269	-0.598	-0.079	0.117	-0.201	-0.208	0.336	0.385	-0.291	0.000 0.240
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WTS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

Fishing Mortalities (F)

	1978	1979	1980	1981	1982
F-values	0.3540	0.3556	0.5118	0.4654	0.6969

	1983	1984	1985	1986	1987	1988	1989	1990	1991
F-values	0.6454	0.6463	0.7447	0.4790	0.4253	0.5872	0.4662	0.5962	0.7116

Selection-at-age (S)

	1	2	3	4	5	6	7	8	9
S-values	0.0034	0.4410	0.9583	1.0000	0.9642	1.1108	1.0852	1.0535	1.0000

Table 25. Yield per recruit and spawning stock biomass per recruit analysis for Georges Bank cod

The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
GEORGES BANK COD

Proportion of F before spawning: .1667
Proportion of M before spawning: .1667
Natural Mortality is Constant at: .200
Initial age is: 1; Last age is: 10
Last age is a PLUS group;

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights[1] Catch	Stock
1	0.0021	1.0000	0.2300	0.973	0.733
2	0.3669	1.0000	0.6400	1.601	1.138
3	0.8145	1.0000	0.9100	2.426	1.949
4	1.0000	1.0000	0.9800	3.571	2.904
5	1.0000	1.0000	1.0000	5.019	4.249
6	1.0000	1.0000	1.0000	6.306	5.742
7	1.0000	1.0000	1.0000	8.029	7.256
8	1.0000	1.0000	1.0000	10.629	9.496
9	1.0000	1.0000	1.0000	11.310	10.854
10+	1.0000	1.0000	1.0000	15.670	15.670

[1]Mean of 1989-1991 catch and stock weights at age

Summary of Yield and SSB per Recruit Analysis for: GEORGES BANK COD

Slope of the Yield/Recruit Curve at F=0.00: -->	27.1476	
F level at slope=1/10 of the above slope ($F_{0.1}$): ---------->		.156
Yield/Recruit corresponding to $F_{0.1}$: -------->	1.6470	
F level to produce Maximum Yield/Recruit (F_{max}):--------- -->		.293
Yield/Recruit corresponding to F_{max}: ------->	1.7815	
F level at 20 % of Max Spawning Potential (F_{20}): ---------->		.353
SSB/Recruit corresponding to F_{20}: ---------->	5.5206	

Listing of Yield and SSB per Recruit Results for: GEORGES BANK COD

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	5.5167	29.5940	4.2370	27.6088	100.00
	.070	.18277	1.17283	4.6068	19.0352	3.3279	17.2083	62.33
	.140	.29121	1.59602	4.0684	13.5735	2.7902	11.8613	42.96
$F_{0.1}$	.156	.31077	1.64697	3.9715	12.6732	2.6934	10.9833	39.78
	.210	.36336	1.74343	3.7113	10.4036	2.4337	8.7760	31.79
	.280	.41506	1.78065	3.4563	8.4114	2.1794	6.8477	24.80
F_{max}	.293	.42327	1.78147	3.4159	8.1185	2.1391	6.5651	23.78
	.350	.45408	1.77284	3.2645	7.0815	1.9882	5.5670	20.16
$F_{20\%}$	.353	.45559	1.77196	3.2571	7.0333	1.9808	5.5206	20.00
	.420	.48471	1.74735	3.1146	6.1499	1.8388	4.6740	16.93
	.490	.50947	1.71608	2.9939	5.4708	1.7185	4.0257	14.58
	.560	.52998	1.68416	2.8943	4.9588	1.6195	3.5390	12.82
	.630	.54729	1.65377	2.8106	4.5617	1.5362	3.1629	11.46
	.700	.56214	1.62568	2.7391	4.2461	1.4651	2.8650	10.38
	.770	.57505	1.60006	2.6773	3.9900	1.4036	2.6240	9.50
	.840	.58641	1.57682	2.6231	3.7783	1.3498	2.4254	8.78
	.910	.59649	1.55577	2.5751	3.6006	1.3022	2.2591	8.18
	.980	.60553	1.53668	2.5324	3.4493	1.2597	2.1181	7.67
	1.050	.61368	1.51932	2.4939	3.3189	1.2215	1.9968	7.23
	1.120	.62109	1.50351	2.4592	3.2055	1.1870	1.8916	6.85
	1.190	.62786	1.48905	2.4275	3.1058	1.1556	1.7993	6.52
	1.260	.63408	1.47579	2.3985	3.0174	1.1269	1.7177	6.22
	1.330	.63982	1.46359	2.3719	2.9385	1.1005	1.6451	5.96
	1.400	.64515	1.45235	2.3474	2.8677	1.0761	1.5800	5.72

Table 26. Input parameters for catch and stock size projections for Georges Bank cod

Input Parameters					
Age	Stock Size in 1992	Fishing Mortality Pattern	Proportion Mature	Average Weights (kg) Catch	Stock
1	10000	0.0021	0.2300	0.973	0.733
2	14943	0.3669	0.6400	1.601	1.138
3	4175	0.8145	0.9100	2.426	1.949
4	3991	1.0000	0.9800	3.571	2.904
5	1878	1.0000	1.0000	5.019	4.249
6	572	1.0000	1.0000	6.306	5.742
7	512	1.0000	1.0000	8.029	7.256
8	59	1.0000	1.0000	10.629	9.496
9	33	1.0000	1.0000	11.310	10.854
10+	21	1.0000	1.0000	15.670	15.670

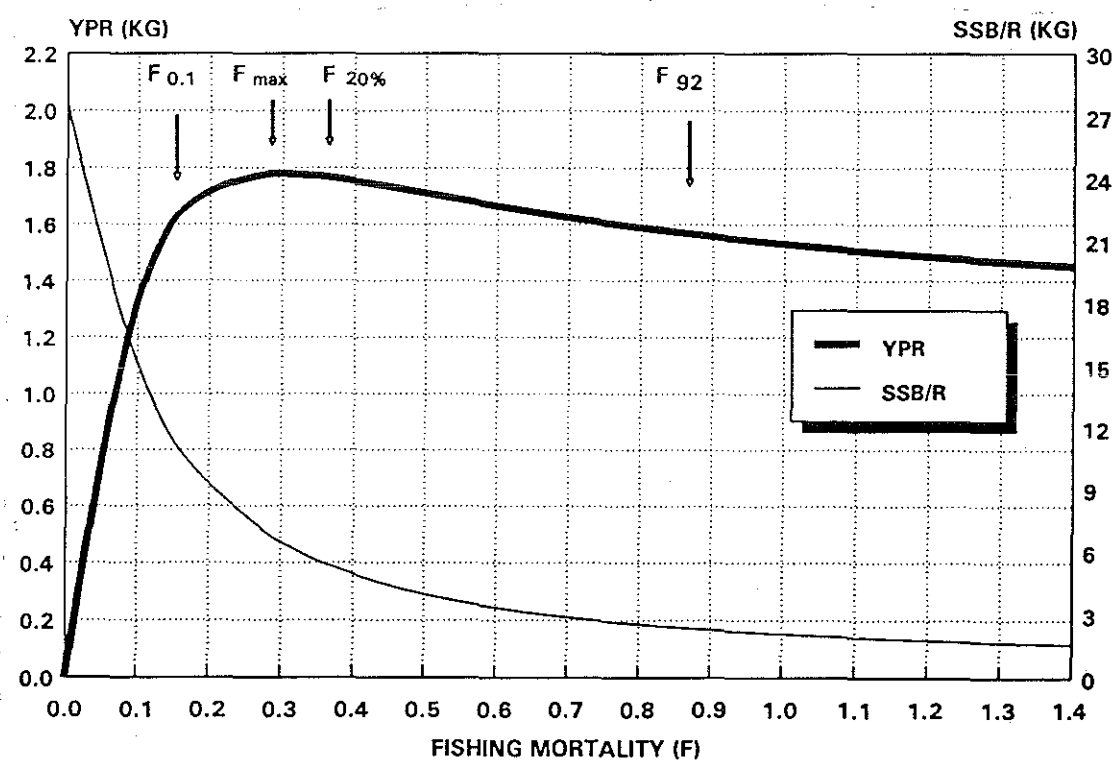

Figure 10. Yield per recruit (YPR) and spawning stock biomass per recruit (SSB/R) for Georges Bank cod.

8. The final exploitation pattern was as follows:

Age 1: 0.0021,
Age 2: 0.3669,
Age 3: 0.8145,
Ages 4+: 1.00.

This pattern is similar to that obtained from the separable VPA and to that presented in the 1991 U.S. cod assessment (Serchuk *et al.* 1991; NEFSC 1992), and was used in the YPR and SSB/R analyses and for the catch and stock size projections for 1993 and 1994.

The input data for the YPR and SSB/R analyses are given in Table 25, and the results are presented in Table 25 and in Figure 10. The results indicate that $F_{0.1} = 0.16$, $F_{max} = 0.29$, and $F_{20\%} = 0.35$. These values are nearly identical to those presented in the 1991 U.S. cod assessment (*i.e.*, $F_{0.1} = 0.16$, $F_{max} = 0.30$, and $F_{20\%} = 0.36$).

Table 27. Recruitment estimates for the 1989-1991 year classes of Georges Bank cod based on NEFSC and Massachusetts trawl surveys

Analysis by RCT3 ver3.1 of data from file : GBCODRCT.DAT GB COD : recruits as 1 group
Data for 8 surveys over 15 years : 1977-1991
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .20
Minimum of 5 points used for regression
Forecast/Hindcast variance correction used

	Regression					Prediction			
Survey/ Series	**Slope**	**Intercept**	**Std Error**	**Rsquare**	**No. Pts**	**Index Value**	**Predicted Value**	**Std Error**	**WAP Weights**
				Yearclass =	**1989**				
NESP1	.70	5.91	.73	.334	12	5.27	9.60	.840	.081
NESP2	.88	3.59	.34	.701	12	6.24	9.09	.418	.329
NEFL0	1.61	.76	1.20	.156	12	5.57	9.75	1.374	.030
NEFL1	.71	4.88	.36	.680	12	5.89	9.09	.437	.300
MASP1	-5.58	50.29	7.49	.005	12	4.11	27.34	10.448	.001
MASP2	1.24	2.79	1.65	.090	12	4.51	8.39	1.949	.015
MAFL0	3.44	-9.56	7.72	.004	10	5.75	10.25	9.052	.001
MAFL1	1.28	4.07	2.31	.045	10	4.71	10.11	2.712	.008
					VPA Mean =		9.92	.494	.235
				Yearclass =	**1990**				
NESP1	.70	5.91	.73	.334	12	6.97	10.79	.870	.073
NESP2	.88	3.59	.34	.701	12	7.14	9.88	.387	.371
NEFL0	1.61	.76	1.20	.156	12	5.06	8.92	1.410	.028
NEFL1	.71	4.88	.36	.680	12	6.03	9.18	.430	.299
MASP1	-5.58	50.29	7.49	.005	12	5.53	19.44	9.152	.001
MASP2									
MAFL0	3.44	-9.56	7.72	.004	10	4.71	6.66	9.145	.001
MAFL1									
					VPA Mean =		9.92	.494	.227
				Yearclass =	**1989**				
NESP1	.70	5.91	.73	.334	12	4.82	9.28	.855	.235
NESP2									
NEFL0	1.61	.76	1.20	.156	12	3.71	6.75	1.704	.059
NEFL1									
MASP1									
MASP2									
MAFL0	3.44	-9.56	7.72	.004	10	8.25	18.85	9.705	.002
MAFL1									
					VPA Mean =		9.92	.494	.704

Year Class	**Weighted Average Prediction**	**Log WAP**	**Int Std Error**	**Ext Std Error**	**Var Ratio**	**VPA**	**Log VPA**
1989	11526	9.35	.24	.20	.69		
1990	16712	9.72	.24	.21	.82		
1991	14745	9.60	.41	.49	1.42		

Table 28. Recruitment estimates for the 1989-1991 year classes of Georges Bank cod based on NEFSC trawl surveys

Analysis by RCT3 ver3.1 of data from file: GBCODRCT.DAT GB COD : recruits as spr 1,2, aut 0,1
Data for 3 surveys over 15 years: 1977-1991
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .20
Minimum of 5 points used for regression
Forecast/Hindcast variance correction used.

	Regression					Prediction			
Survey/ Series	Slope	Intercept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
				Yearclass = 1989					
NESP1	.70	5.91	.73	.334	12	5.27	9.60	.840	.086
NESP2	.88	3.59	.34	.701	12	6.24	9.09	.418	.348
NEFL1	.71	4.88	.36	.680	12	5.89	9.09	.437	.318
					VPA Mean =		9.92	.494	.248
				Yearclass =1990					
NESP1	.70	5.91	.73	.334	12	6.97	10.79	.870	.075
NESP2	.88	3.59	.34	.701	12	7.14	9.88	.387	.382
NEFL1	.71	4.88	.36	.680	12	6.03	9.18	.430	.308
					VPA Mean =		9.92	.494	.234
				Yearclass =1991					
NESP1	.70	5.91	.73	.334	12	4.82	9.28	.855	.251
NESP2									
NEFL1									
					VPA Mean =		9.92	.494	.749

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
1989	11362	9.34	.25	.21	.73		
1990	17027	9.74	.24	.25	1.12		
1991	17335	9.76	.43	.28	.42		

PROJECTIONS FOR 1993 AND 1994

Landings and stock sizes were projected through 1993 at various levels of F and recruitment, assuming that total landings in 1992 (based on an estimate from preliminary landings data) would be 28,100 mt. To estimate F_{1992}, the projection model was iterated until the accumulated catch over all ages equalled 28,100 mt. The resulting F_{1992} (ages 4 to 8, unweighted) was 0.87.

The exploitation pattern, mean weights and maturation rates used in the projections (Table 26) were the same as those used in the YPR and SSB/R analyses. Survivors at ages 2 to 10+, taken from the final VPA, were used to start the projections in 1992.

For comparison with the VPA estimates of recruitment at age 1 for the 1989, 1990 and 1991 year classes (the most important cohorts in the projections), RCT3 analyses were performed (with shrinkage to the VPA mean applied) using spring and autumn NEFSC and Commonwealth of Massachusetts survey data. The initial RCT3 run (Table 27) indicated that reasonable correlations

with VPA age 1 stock sizes were only evident for the NEFSC spring age 1 and 2 and NEFSC autumn age 1 indices. The final RCT3 was subsequently run using only these three indices (Table 28).

For the 1989 year class (age 1 in 1990), there was no overriding reason to replace the VPA estimate (8.3 million at age 1: Table 20) with the RCT3 estimate (11.4 million fish at age 1: Table 28). The two survey indices with good correlations (NEFSC spring age 2 and NEFSC autumn age 1) both gave year class strengths very similar to the VPA estimate (*i.e.*, exp 9.09 = 8.9 million fish at age 1) (Table 28).

For the 1990 year class, the RCT3 estimate (17 million fish at age 1) was also quite similar to that estimated by the VPA (18.3 million fish at age 1). The VPA estimate was therefore carried forward into the projections. In the 1991 assessment, the 1990 year class was estimated at 28 million fish at age 1. Thus, it now appears that the strength of the 1990 cohort was overestimated in the 1991 assessment.

The VPA estimate for the 1991 year class of 3.3 million fish at age 1 (Table 20) differed markedly from the RCT3 estimate (17.3 million fish at age 1: Table 28). Taken at face value, the VPA estimate indicates a year class strength for the 1991 cohort that is 60% lower than the poorest year class in the VPA time series (*i.e.*, the 1989 year class of 8.3 million fish at age 1), while the RCT3 estimate indicates the 1991 cohort to be just slightly below-average. However, the RCT3 estimate approximates the VPA average only because the VPA mean receives 75% of the weight in the RCT3 prediction. This is because the NEFSC spring age 1 index [the only index available for estimating the 1991 cohort] is not well correlated with the VPA (r^2 = 0.33) - and hence is downweighted in the RCT3 prediction (Table 28). If the RCT3 estimate is not shrunk to the mean, the NEFSC spring age 1 index predicts the 1991 year class to be 10.7 million fish at age 1 (*i.e.*, exp 9.28 = 10.7 million: Table 28), or about half the VPA geometric mean stock size at age 1 (exp 9.92 = 20.3 million: Table 28). Given the imprecision of the survey-based predictions and the high CV associated with the VPA estimate of the 1991 year class in 1992 (Table 21), neither the VPA or RCT3 estimates were accepted at face value. Instead, the 1991 year class was considered to be substantially below-average and assumed, in the predictions, to be 10 million fish at age 1 (*i.e.*, about half of the long-term mean).

Input data for the projections are listed in Table 26. The forecasts for 1993-1994 were run under three different recruitment options for the strengths of the 1992 and 1993 year classes:

(1) assuming these year classes will be equal to the lowest previously observed [8.3 million fish at age 1];
(2) assuming these year classes will be equal to the geometric mean of the 1977-1988 year classes [20.7 million fish at age 1]; and
(3) assuming these year classes will be equal to the highest ever observed [42.4 million fish at age 1].

The F options used in the forecasts included: F_{max}, $F_{20\%}$, $0.9F_{92}$, and F_{92}.

Under all three of the recruitment options, continued fishing at the 1992 level (F = 0.87) will lead to landings in 1993 declining to their lowest level (24,500 mt) since 1976 (Table 29). If recruitment of the 1992 and 1993 year classes is average, SSB will decline from 41,000 mt in 1992 to a new record low of 37,500 mt in 1993 and 1994 (Figure 11).

If recruitment in 1993 and 1994 is below average and $F_{93} = F_{92}$, SSB in 1994 will be much lower than 37,000 mt. Conversely, even if recruitment in 1993 and 1994 is equal to the highest on record, continued fishing in 1993 at the 1992 F level will only result in an increase in SSB in 1994 to near the low 1991 level of 55,000 mt (Table 29).

CONCLUSIONS

The Georges Bank cod stock is at a low biomass level and is overexploited. Fishing mortality in 1991 increased to a record-high level while spawning stock biomass declined to a record low. Recent recruitment has been below average or poor. Accounting for the estimation uncertainty associated with the 1991 SSB (54,700 mt) and 1991 F (1.07) estimates, there is an 80% probablity that the 1991 SSB lies between 48,000 and 61,000 mt, and that the 1991 F lies between 0.86 and 1.22. This further implies a 90% probability that the 1991 F was greater than 0.86 (*i.e*, 2.5 times the overfishing definition, $F_{20\%}$ = 0.35).

Continued fishing at current levels of fishing mortality will result in further declines in SSB to all-time low levels. At a minimum, fishing mortality should be reduced to avoid further declines in stock size. A 10% reduction in fishing mortality in 1993 would not result in any appreciable short-term increase in SSB between 1993 and 1994. Recovery of the stock will require a marked reduction in fishing mortality.

Table 29. Forecasted landings of Georges Bank cod in 1993 and spawning stock biomass in 1993 and 1994. Projections were run under three different recruitment options: (1) assuming the 1992 and 1993 year classes will be equal to the lowest ever observed [8.3 million at fish age 1]; (2) assuming the 1992 and 1993 year classes will be equal to the 1978-1989 average [20.7 million fish at age 1]; and (3) assuming that the 1992 and 1993 year classes will be equal to the highest ever observed [42.4 million fish at age 1]. In all of the forecasts, the strength of the 1991 year class was assumed to be 10 million fish at age 1 (*i.e.*, about half the size of an average year class).

Recruitment in 1993-94 (No. fish at Age 1)	1992			1993				1994
	F(92)	Landings (mt)	SSB (mt)	Basis	F(93)	Landings (mt)	SSB (mt)	SSB (mt)
8.3 million	0.87	28104	41066	F_{max}	0.29	10237	38218	44579
	0.87	28104	41066	$F_{20\%}$	0.35	12048	37914	42488
	0.87	28104	41066	$0.9F_{92}$	0.78	22702	35823	30685
	0.87	28104	41066	F_{92}	0.87	24465	35413	28822
20.7 million	0.87	28104	41066	F_{max}	0.29	10244	40233	53590
	0.87	28104	41066	$F_{20\%}$	0.35	12056	39929	51474
	0.87	28104	41066	$0.9F_{92}$	0.78	22720	37838	39484
	0.87	28104	41066	F_{92}	0.87	24485	37428	37584
42.4 million	0.87	28104	41066	F_{max}	0.29	10255	43778	69439
	0.87	28104	41066	$F_{20\%}$	0.35	12070	43473	67276
	0.87	28104	41066	$0.9F_{92}$	0.78	22751	41382	54959
	0.87	28104	41066	F_{92}	0.87	24520	40972	52993

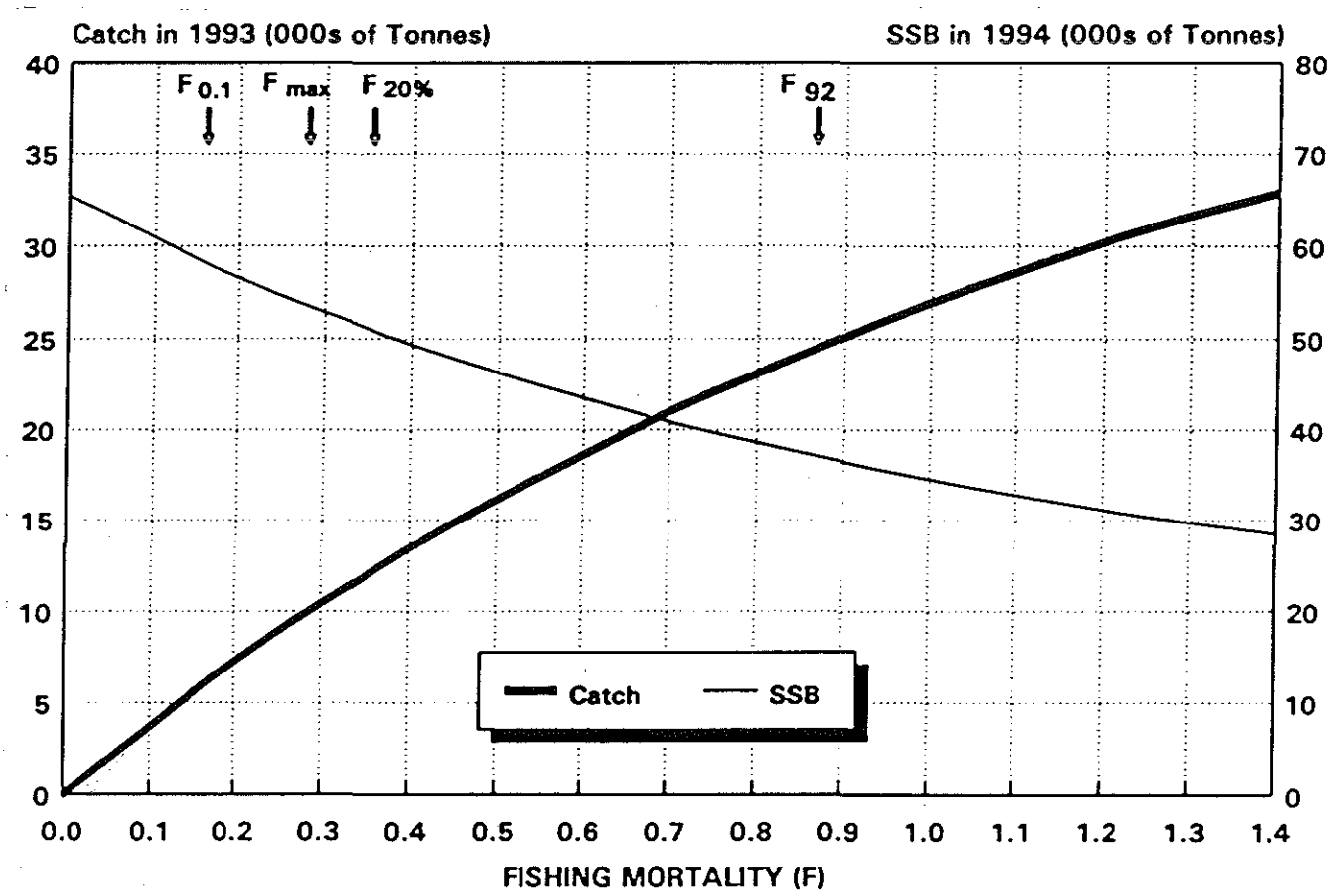

Figure 11. Predicted catches in 1993 and spawning stock biomasses in 1994 of Georges Bank cod over a range of fishing mortalities in 1993 from F=0 to F=1.4.

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Appendix

Full Listing of Final ADAPT Calibration Run for Georges Bank Cod

Appendix 1. Full listing of final ADAPT calibration run for Georges Bank cod.

```
ADAPT        Run Number 259          1992 12 9 12 19 2
COD: GEORGES BANK STOCK - GBCOD92M: Linear time-tapered weighting and
                        Iterative re-weighting of indices applied.

Output option selected for input parameters:  full
Output option selected for results:  full

INPUT PARAMETERS AND OPTIONS SELECTED
-------------------------------------
Natural mortality is 0.2
Oldest age (not in the plus group) is 9

For all yrs prior to the terminal year (1991), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age 9:    4 5 6 7 8 9
This method for estimating F on the oldest age is generally used
when a flat-topped partial recruitment curve is thought to be
characteristic of the stock.

F for age 10+ is then calculated from the following
ratios of F[age 10+] to F[age 9]
      1978    1.0000
      1979    1.0000
      1980    1.0000
      1981    1.0000
      1982    1.0000
      1983    1.0000
      1984    1.0000
      1985    1.0000
      1986    1.0000
      1987    1.0000
      1988    1.0000
      1989    1.0000
      1990    1.0000
      1991    1.0000
Stock size of the 10+ group is then calculated
using the following method:  CATCHEQ

Partial recruitment estimate for 1991
        1    0.0034
        2    0.4410
        3    0.9583
        4    1.0000
        5    1.0000
        6    1.0000
        7    1.0000
        8    1.0000
        9    1.0000

Objective function is    SUM w*( LOG(OBS) - LOG(PRED) )**2

Indices normalized (by dividing by mean observed value)
before tuning to VPA stocksizes

The residuals for years prior to the terminal year are downweighted
using the following algorithm:  LINEAR
In 1981 (and earlier years), downweight will be zero

Biomass estimates (other than SSB) reflect mean stock sizes.
SSB calculated as in the NEFSC projection program
(see note below SSB table for description of the algorithm).
```

Initial estimates of parameters for the Marquardt algorithm
and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 1	2.0000000E3	1.0000000E0	1.0000000E6
N 2	9.0000000E3	1.0000000E0	1.0000000E6
N 3	4.0000000E3	1.0000000E0	1.0000000E6
N 4	5.0000000E3	1.0000000E0	1.0000000E6
N 5	2.0000000E3	1.0000000E0	1.0000000E6
N 6	2.0000000E3	1.0000000E0	1.0000000E6
qRV SPR 1	1.0000000E-4	0.0000000E0	1.0000000E0
qRV SPR 2	1.0000000E-4	0.0000000E0	1.0000000E0
qRV SPR 3	1.0000000E-4	0.0000000E0	1.0000000E0
qRV SPR 4	1.0000000E-4	0.0000000E0	1.0000000E0
qRV SPR 5	1.0000000E-4	0.0000000E0	1.0000000E0
qRV SPR 6	1.0000000E-4	0.0000000E0	1.0000000E0
qRV FAL 1	1.0000000E-4	0.0000000E0	1.0000000E0
qRV FAL 2	1.0000000E-4	0.0000000E0	1.0000000E0
qRV FAL 3	1.0000000E-4	0.0000000E0	1.0000000E0
qRV FAL 4	1.0000000E-4	0.0000000E0	1.0000000E0
qRV FAL 5	1.0000000E-4	0.0000000E0	1.0000000E0
qRV FAL 6	1.0000000E-4	0.0000000E0	1.0000000E0
qCM CPE 2	1.0000000E-4	0.0000000E0	1.0000000E0
qCM CPE 3	1.0000000E-4	0.0000000E0	1.0000000E0
qCM CPE 4	1.0000000E-4	0.0000000E0	1.0000000E0
qCM CPE 5	1.0000000E-4	0.0000000E0	1.0000000E0
qCM CPE 6	1.0000000E-4	0.0000000E0	1.0000000E0

The following indices of abundance are available:

1	RV SPR 1
2	RV SPR 2
3	RV SPR 3
4	RV SPR 4
5	RV SPR 5
6	RV SPR 6
7	RV FAL 1
8	RV FAL 2
9	RV FAL 3
10	RV FAL 4
11	RV FAL 5
12	RV FAL 6
13	CM CPE 2
14	CM CPE 3
15	CM CPE 4
16	CM CPE 5
17	CM CPE 6
18	MA SP 1
19	MA SP 2
20	MA SP 3
21	MA FAL 1
22	MA FAL 2
23	
24	
25	
26	
27	
28	
29	
30	

Indices that will be used in this run are: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Obs Indices (before transformation) by index & yr; with index means

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992*******	
1	0.376	0.435	0.039	2.303	0.488	0.329	0.402	0.098	0.871	0.034	0.700	0.380	0.194	1.068	0.123	0.523
2	0.187	1.359	2.265	1.916	3.395	1.967	0.462	2.633	0.423	1.612	0.684	1.334	0.926	0.511	1.255	1.395
3	5.530	0.298	2.688	2.779	1.406	3.048	0.797	0.757	1.824	0.403	3.115	0.743	1.707	0.807	0.470	1.758
4	0.969	1.913	0.209	1.667	1.295	0.766	1.161	1.058	0.360	0.752	0.413	1.532	0.653	0.883	0.163	0.920
5	0.778	0.541	1.482	0.100	1.039	0.697	0.446	1.328	0.545	0.060	0.645	0.228	0.896	0.465	0.270	0.635
6	0.144	0.234	0.597	0.870	0.016	0.431	0.424	0.270	0.633	0.179	0.045	0.344	0.125	0.336	0.144	0.319
7	0.152	0.396	0.118	0.280	0.261	0.320	1.031	0.186	1.084	0.096	0.204	0.549	0.262	0.156	0.040	0.342
8	0.237	1.855	1.619	0.818	3.525	0.875	0.647	2.496	0.220	2.280	0.414	0.903	2.738	0.362	0.415	1.294
9	3.424	0.255	1.717	0.564	2.250	2.094	1.022	0.101	0.803	0.153	1.353	0.433	1.030	1.534	0.168	1.127
10	0.702	4.180	0.224	0.774	1.559	0.220	0.796	0.886	0.103	0.382	0.112	0.909	0.183	1.164	0.277	0.831
11	0.251	0.964	1.613	0.076	0.589	0.069	0.055	0.870	0.115	0.010	0.195	0.091	0.499	0.209	0.028	0.376
12	0.174	0.335	0.296	0.251	0.054	0.097	0.047	0.017	0.101	0.061	0.028	0.178	0.055	0.145	0.029	0.125
13	0.024	0.075	0.121	0.117	0.293	0.106	0.038	0.113	0.034	0.145	0.038	0.049	0.126	0.028	-999.000	0.093
14	0.418	0.027	0.190	0.139	0.092	0.167	0.098	0.041	0.103	0.024	0.159	0.073	0.090	0.073	-999.000	0.121
15	0.119	0.191	0.012	0.075	0.063	0.037	0.088	0.026	0.014	0.041	0.019	0.089	0.035	0.055	-999.000	0.062
16	0.046	0.042	0.076	0.004	0.047	0.026	0.015	0.037	0.011	0.006	0.030	0.006	0.040	0.023	-999.000	0.029
17	0.004	0.019	0.038	0.039	0.004	0.022	0.012	0.007	0.013	0.005	0.005	0.010	0.004	0.015	-999.000	0.014

SUMMARY OF WEIGHTING USED IN THE OBJECTIVE FUNCTION

EXOGENOUS WEIGHTS BY INDEX AND YR (omega)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00

Negative weights in the above table indicate missing values

DOWNWEIGHTS BY YEAR (delta)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	0.0000	0.0000	0.0000	0.0000	0.1000	0.2000	0.3000	0.4000	0.5000	0.6000	0.7000	0.8000	0.9000	1.0000	1.0000

ITERATIVE RE-WEIGHTS BY INDEX (chi)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	0.0080	0.0802	0.1234	0.0210	0.0329	0.0258	0.0163	0.0174	0.0150	0.0140	0.0090	0.0229	0.0409	0.1666	0.0926	0.0630	0.2509

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0008	0.0016	0.0024	0.0032	0.0040	0.0048	0.0056	0.0064	0.0072	0.0080	0.0080
2	0.0000	0.0000	0.0000	0.0000	0.0080	0.0160	0.0241	0.0321	0.0401	0.0481	0.0562	0.0642	0.0722	0.0802	0.0802
3	0.0000	0.0000	0.0000	0.0000	0.0123	0.0247	0.0370	0.0494	0.0617	0.0740	0.0864	0.0987	0.1110	0.1234	0.1234
4	0.0000	0.0000	0.0000	0.0000	0.0021	0.0042	0.0063	0.0084	0.0105	0.0126	0.0147	0.0168	0.0189	0.0210	0.0210
5	0.0000	0.0000	0.0000	0.0000	0.0033	0.0066	0.0099	0.0131	0.0164	0.0197	0.0230	0.0263	0.0296	0.0329	0.0329
6	0.0000	0.0000	0.0000	0.0000	0.0026	0.0052	0.0077	0.0103	0.0129	0.0155	0.0181	0.0206	0.0232	0.0258	0.0258
7	0.0000	0.0000	0.0000	0.0000	0.0016	0.0033	0.0049	0.0065	0.0082	0.0098	0.0114	0.0131	0.0147	0.0163	0.0163
8	0.0000	0.0000	0.0000	0.0000	0.0017	0.0035	0.0052	0.0070	0.0087	0.0105	0.0122	0.0140	0.0157	0.0174	0.0174
9	0.0000	0.0000	0.0000	0.0000	0.0015	0.0030	0.0045	0.0060	0.0075	0.0090	0.0105	0.0120	0.0135	0.0150	0.0150
10	0.0000	0.0000	0.0000	0.0000	0.0014	0.0028	0.0042	0.0056	0.0070	0.0084	0.0098	0.0112	0.0126	0.0140	0.0140
11	0.0000	0.0000	0.0000	0.0000	0.0009	0.0018	0.0027	0.0036	0.0045	0.0054	0.0063	0.0072	0.0081	0.0090	0.0090
12	0.0000	0.0000	0.0000	0.0000	0.0023	0.0046	0.0069	0.0092	0.0115	0.0138	0.0160	0.0183	0.0206	0.0229	0.0229
13	0.0000	0.0000	0.0000	0.0000	0.0041	0.0082	0.0123	0.0164	0.0205	0.0245	0.0286	0.0327	0.0368	0.0409	-99.0000
14	0.0000	0.0000	0.0000	0.0000	0.0167	0.0333	0.0500	0.0667	0.0833	0.1000	0.1166	0.1333	0.1500	0.1666	-99.0000
15	0.0000	0.0000	0.0000	0.0000	0.0093	0.0185	0.0278	0.0370	0.0463	0.0556	0.0648	0.0741	0.0834	0.0926	-99.0000
16	0.0000	0.0000	0.0000	0.0000	0.0063	0.0126	0.0189	0.0252	0.0315	0.0378	0.0441	0.0504	0.0567	0.0630	-99.0000
17	0.0000	0.0000	0.0000	0.0000	0.0251	0.0502	0.0753	0.1004	0.1255	0.1506	0.1756	0.2007	0.2258	0.2509	-99.0000

Negative weights in the above table indicate missing values

CATCH AT AGE (millions) - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	2.000	34.000	89.000	27.000	331.000	108.000	81.000	134.000	156.000	26.000	10.000
2	393.000	1989.000	3777.000	3205.000	9138.000	4286.000	1307.000	6426.000	1326.000	7473.000	1577.000
3	7748.000	900.000	5828.000	4221.000	3824.000	8063.000	3423.000	2443.000	4573.000	1406.000	8022.000
4	2303.000	4870.000	500.000	2464.000	2787.000	2456.000	3336.000	1368.000	797.000	2121.000	1012.000
5	830.000	1212.000	2308.000	235.000	2000.000	1055.000	840.000	1885.000	480.000	279.000	1497.000
6	131.000	458.000	1076.000	1406.000	281.000	776.000	516.000	412.000	627.000	252.000	244.000
7	345.000	77.000	445.000	417.000	673.000	95.000	458.000	218.000	87.000	270.000	161.000
8	47.000	253.000	87.000	123.000	213.000	235.000	44.000	203.000	72.000	63.000	197.000
9	40.000	4.000	167.000	130.000	71.000	100.000	171.000	21.000	47.000	38.000	50.000
10	15.000	48.000	10.000	62.000	83.000	65.000	121.000	97.000	29.000	24.000	47.000
1+	11854.000	9845.000	14287.000	12290.000	19401.000	17239.000	10297.000	13207.000	8194.000	11952.000	12817.000

	1989	1990	1991
1	0.001	7.000	52.000
2	2088.000	4942.000	1525.000
3	2922.000	5042.000	3243.000
4	4155.000	1882.000	3281.000
5	331.000	2264.000	1458.000
6	541.000	229.000	1088.000
7	82.000	245.000	126.000
8	43.000	36.000	70.000
9	50.000	17.000	23.000
10	18.000	38.000	23.000
1+	10230.001	14702.000	10889.000

CAA summary for ages 2 8 3 8 4 8 5 8 6 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	11797.000	9759.000	14021.000	12071.000	18916.000	16966.000	9924.000	12955.000	7962.000	11864.000	12710.000
3	11404.000	7770.000	10244.000	8866.000	9778.000	12680.000	8617.000	6529.000	6636.000	4391.000	11133.000
4	3656.000	6870.000	4416.000	4645.000	5954.000	4617.000	5194.000	4086.000	2063.000	2985.000	3111.000
5	1353.000	2000.000	3916.000	2181.000	3167.000	2161.000	1858.000	2718.000	1266.000	864.000	2099.000
6	523.000	788.000	1608.000	1946.000	1167.000	1106.000	1018.000	833.000	786.000	585.000	602.000

	1989	1990	1991
2	10162.000	14640.000	10791.000
3	8074.000	9698.000	9266.000
4	5152.000	4656.000	6023.000
5	997.000	2774.000	2742.000
6	666.000	510.000	1284.000

WT AT AGE (MID-YR) in kg. - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.707	0.889	0.836	0.882	0.765	0.971	1.053	0.907	0.929	0.726	0.786	0.809	0.831	1.114
2	1.310	1.494	1.460	1.495	1.402	1.490	1.635	1.418	1.475	1.481	1.520	1.617	1.560	1.627
3	2.461	2.149	2.468	2.358	2.664	2.377	2.451	2.086	2.447	2.495	2.359	2.269	2.462	2.548
4	3.469	4.211	3.668	3.415	3.834	3.309	3.619	3.887	3.660	4.187	3.511	3.772	3.522	3.420
5	4.336	4.888	5.647	5.213	5.352	4.637	5.083	5.087	5.603	5.810	5.401	5.396	4.892	4.769
6	5.787	7.178	6.676	7.222	6.511	6.393	6.582	6.412	7.191	7.726	6.647	6.694	6.333	5.891
7	7.374	9.183	8.390	8.565	9.363	7.964	8.909	8.097	8.915	8.949	8.776	8.222	8.456	7.410
8	8.492	10.313	9.089	9.888	9.897	10.286	10.104	10.236	9.955	10.013	9.987	10.718	10.648	10.520
9	11.785	11.699	8.432	14.170	12.503	11.227	11.303	11.418	12.687	11.414	11.143	11.665	12.580	9.686
10	13.200	12.625	15.400	18.565	16.723	14.554	15.356	13.494	14.104	15.000	15.298	17.111	14.526	15.373

WT AT AGE (JAN 1) in kg. - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.486	0.694	0.625	0.700	0.548	0.748	0.907	0.711	0.736	0.502	0.548	0.583	0.594	1.067	0.659
2	1.023	1.028	1.139	1.118	1.112	1.068	1.260	1.222	1.157	1.173	1.050	1.127	1.123	1.163	1.163
3	1.881	1.678	1.920	1.855	1.996	1.826	1.911	1.847	1.863	1.918	1.869	1.857	1.995	1.994	2.277
4	2.922	3.219	2.808	2.903	3.007	2.969	2.933	3.087	2.763	3.201	2.960	2.983	2.827	2.902	3.256
5	3.370	4.118	4.876	4.373	4.275	4.216	4.101	4.291	4.667	4.611	4.755	4.353	4.296	4.098	4.031
6	4.594	5.579	5.712	6.386	5.826	5.849	5.525	5.709	6.048	6.579	6.214	6.013	5.846	5.368	5.549
7	6.235	7.290	7.760	7.562	8.223	7.201	7.547	7.300	7.561	8.022	8.234	7.393	7.524	6.850	6.465
8	7.235	8.721	9.136	9.108	9.207	9.814	8.970	9.549	8.978	9.448	9.454	9.699	9.357	9.432	8.015
9	10.004	9.967	9.325	11.349	11.119	10.541	10.783	10.741	11.396	10.660	10.563	10.793	11.612	10.156	11.734
10	13.200	12.625	15.400	18.565	16.723	14.554	15.356	13.494	14.104	15.000	15.298	17.111	14.526	15.373	15.373

Weights at age at the start of the spawning season are assumed
to be the same as the Jan1 weight at age estimates.

PERCENT MATURE (females) - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	7	7	7	7	13	13	13	13	23	23	23	23	23	23
2	34	34	34	34	47	47	47	47	64	64	64	64	64	64
3	78	78	78	78	84	84	84	84	91	91	91	91	91	91
4	96	96	96	96	97	97	97	97	98	98	98	98	98	98
5	100	100	100	100	100	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100	100	100	100	100	100

SEX RATIO (Percent Female) - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5	50	50	50	50	50	50	50	50	50	50	50	50	50	50
6	50	50	50	50	50	50	50	50	50	50	50	50	50	50
7	50	50	50	50	50	50	50	50	50	50	50	50	50	50
8	50	50	50	50	50	50	50	50	50	50	50	50	50	50
9	50	50	50	50	50	50	50	50	50	50	50	50	50	50
10	50	50	50	50	50	50	50	50	50	50	50	50	50	50

BEGIN MARQUARDT ALGORITHM

LAMBDA 1.00000E-2
RSS 9.36202E0
NPHI 9.36202E0

par
2.00000E3 9.00000E3 4.00000E3 5.00000E3 2.00000E3 2.00000E3 1.00000E-4 1.00000E-4 1.
00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1
.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4 1.00000E-4

LAMBDA 1.00000E-1
RSS 7.83535E0
NPHI 7.83535E0

par
2.09334E3 9.43395E3 4.00444E3 4.87356E3 1.96898E3 1.75877E3 9.16490E-5 9.32976E-5 9.
59209E-5 1.03699E-4 1.11627E-4 1.19683E-4 9.26026E-5 9.19914E-5 9.48222E-5 9.99003E-5 1
.03998E-4 1.17507E-4 9.51519E-5 9.93771E-5 1.07067E-4 1.14839E-4 1.22484E-4

LAMBDA 1.00000E0
RSS 6.57673E0
NPHI 6.57673E0

par
2.18041E3 9.84115E3 4.01020E3 4.76838E3 1.95317E3 1.57281E3 8.48143E-5 8.76829E-5 9.
23516E-5 1.06989E-4 1.23049E-4 1.40779E-4 8.64767E-5 8.53934E-5 9.03699E-5 9.96797E-5 1
.07509E-4 1.35901E-4 9.09650E-5 9.87067E-5 1.13656E-4 1.30011E-4 1.47194E-4

LAMBDA 1.00000E-1

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RSS             1.93494E0
NPHI            1.93494E0

par
   2.82230E3      1.30001E4      3.99047E3      3.99475E3      2.31910E3      5.97311E2      3.32067E-5     4.34638E-5     6.
      17512E-5       1.30177E-4     2.17545E-4     3.36456E-4     3.98287E-5     3.42425E-5     5.31813E-5     9.32686E-5     1
      .28694E-4      3.02269E-4     5.58706E-5     8.93227E-5     1.64045E-4     2.63832E-4     3.86612E-4

LAMBDA          1.00000E-2
RSS             7.23363E-1
NPHI            7.23363E-1

par
   3.24836E3      1.48383E4      4.17762E3      4.00378E3      1.89283E3      5.81481E2      4.12007E-5     4.94593E-5     6.
      45880E-5       1.39062E-4     2.88979E-4     5.84852E-5     4.59749E-5     4.26580E-5     5.77394E-5     9.54608E-5     1
      .40872E-4      4.92475E-4     5.97801E-5     9.08815E-5     1.90745E-4     3.90089E-4     7.23949E-4

LAMBDA          1.00000E-3
RSS             6.24428E-1
NPHI            6.24428E-1

par
   3.27469E3      1.49437E4      4.17470E3      3.99143E3      1.87922E3      5.70968E2      4.23371E-5     4.99828E-5     6.
      47572E-5       1.39742E-4     3.04060E-4     6.98649E-4     4.65666E-5     4.38731E-5     5.80442E-5     9.57189E-5     1
      .42373E-4      5.66153E-4     6.00165E-5     9.10697E-5     1.93955E-4     4.26601E-4     9.08175E-4

LAMBDA          1.00000E-4
RSS             6.23376E-1
NPHI            6.23376E-1

par
   3.27459E3      1.49433E4      4.17460E3      3.99077E3      1.87800E3      5.71921E2      4.23489E-5     4.99839E-5     6.
      47575E-5       1.39744E-4     3.04403E-4     7.09707E-4     4.65687E-5     4.38861E-5     5.80445E-5     9.57201E-5     1
      .42376E-4      5.71462E-4     6.00167E-5     9.10705E-5     1.93969E-4     4.28129E-4     9.32509E-4

LAMBDA          1.00000E-5
RSS             6.23376E-1
NPHI            6.23376E-1

par
   3.27457E3      1.49432E4      4.17456E3      3.99068E3      1.87796E3      5.71808E2      4.23491E-5     4.99843E-5     6.
      47580E-5       1.39746E-4     3.04407E-4     7.09768E-4     4.65690E-5     4.38863E-5     5.80450E-5     9.57212E-5     1
      .42379E-4      5.71483E-4     6.00171E-5     9.10714E-5     1.93972E-4     4.28136E-4     9.32736E-4

RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001


RESULTS
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APPROX STATISTICS ASSUMING LINEARITY IN THE NEIGHBORHOOD OF SOLUTION

SUM OF SQUARES	0.623376
ORTHOGONALITY OFFSET.....	0.001506
MEAN SQUARE RESIDUALS	0.002746

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 1	3.27457E3	1.20831E3	2.71003E0	0.37
N 2	1.49432E4	2.47910E3	6.02766E0	0.17
N 3	4.17456E3	4.99989E2	8.34931E0	0.12
N 4	3.99068E3	5.21526E2	7.65194E0	0.13
N 5	1.87796E3	3.12343E2	6.01249E0	0.17
N 6	5.71808E2	1.05684E2	5.41057E0	0.18
qRV SPR 1	4.23491E-5	1.01924E-5	4.15498E0	0.24
qRV SPR 2	4.99843E-5	3.99641E-6	1.25073E1	0.08
qRV SPR 3	6.47580E-5	4.13297E-6	1.56686E1	0.06
qRV SPR 4	1.39746E-4	2.02379E-5	6.90514E0	0.14
qRV SPR 5	3.04407E-4	3.59531E-5	8.46677E0	0.12
qRV SPR 6	7.09768E-4	9.51629E-5	7.45845E0	0.13
qRV FAL 1	4.65690E-5	8.16243E-6	5.70528E0	0.18
qRV FAL 2	4.38863E-5	7.01275E-6	6.25808E0	0.16
qRV FAL 3	5.80450E-5	9.89407E-6	5.86664E0	0.17
qRV FAL 4	9.57212E-5	1.69131E-5	5.65958E0	0.18
qRV FAL 5	1.42379E-4	3.13214E-5	4.54574E0	0.22
qRV FAL 6	5.71483E-4	8.09159E-5	7.06268E0	0.14
qCM CPE 2	6.00171E-5	6.81977E-6	8.80046E0	0.11
qCM CPE 3	9.10714E-5	5.39828E-6	1.68704E1	0.06
qCM CPE 4	1.93972E-4	1.50285E-5	1.29070E1	0.08
qCM CPE 5	4.28136E-4	3.99486E-5	1.07172E1	0.09
qCM CPE 6	9.32736E-4	4.63670E-5	2.01164E1	0.05

Variance estimates via linearization assume that at the solution,
the norm of the residuals will be small relative to the
norm of the J'J matrix (where J is the Jacobian)

PARAMETER	|| residuals ||	norms of the cols of J'J	Quotient
N 1	7.89542E-1	1.20390E-1	6.55819E0
N 2		1.12697E-1	7.00588E0
N 3		5.64618E-1	1.39836E0
N 4		4.73185E-1	1.66857E0
N 5		4.62834E-1	1.70589E0
N 6		8.46202E-1	9.33042E-1
qRV SPR 1		2.87043E7	2.75061E-8
qRV SPR 2		2.06706E8	3.81963E-9
qRV SPR 3		1.89354E8	4.16966E-9
qRV SPR 4		6.91609E6	1.14160E-7
qRV SPR 5		2.28186E6	3.46008E-7
qRV SPR 6		3.29466E5	2.39643E-6
qRV FAL 1		4.84396E7	1.62995E-8
qRV FAL 2		5.82947E7	1.35440E-8
qRV FAL 3		2.86592E7	2.75493E-8
qRV FAL 4		9.80116E6	8.05560E-8
qRV FAL 5		2.85604E6	2.76447E-7
qRV FAL 6		4.51663E5	1.74808E-6
qCM CPE 2		6.18324E7	1.27691E-8
qCM CPE 3		1.09410E8	7.21634E-9
qCM CPE 4		1.34045E7	5.89012E-8
qCM CPE 5		1.87173E6	4.21824E-7
qCM CPE 6		1.57059E6	5.02705E-7

Frobenius Norm of J'J is	319545634.5
Std Natural Norm of J'J is	206706251.2

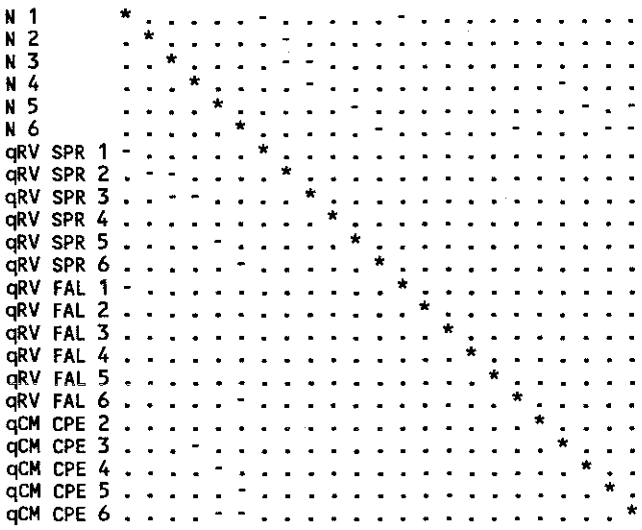
CATCHABILITY ESTIMATES IN ORIGINAL UNITS

	ESTIMATE	STD. ERR.	C.V.
qRV SPR 1	2.21391E-5	5.32834E-6	0.24
qRV SPR 2	6.97446E-5	5.57632E-6	0.08
qRV SPR 3	1.13853E-4	7.26633E-6	0.06
qRV SPR 4	1.28503E-4	1.86097E-5	0.14
qRV SPR 5	1.93194E-4	2.28179E-5	0.12
qRV SPR 6	2.26747E-4	3.04013E-5	0.13
qRV FAL 1	1.59425E-5	2.79433E-6	0.18
qRV FAL 2	5.67714E-5	9.07169E-6	0.16
qRV FAL 3	6.54034E-5	1.11484E-5	0.17
qRV FAL 4	7.95882E-5	1.40626E-5	0.18
qRV FAL 5	5.34782E-5	1.17644E-5	0.22
qRV FAL 6	7.12054E-5	1.00819E-5	0.14
qCM CPE 2	5.60628E-6	6.37044E-7	0.11
qCM CPE 3	1.10055E-5	6.52352E-7	0.06
qCM CPE 4	1.19520E-5	9.26009E-7	0.08
qCM CPE 5	1.24579E-5	1.16242E-6	0.09
qCM CPE 6	1.31293E-5	6.52666E-7	0.05

CORRELATION BETWEEN PARAMETERS ESTIMATED

1.00	0.09	0.05	0.03	0.02	0.01	-0.25	-0.04	-0.02	-0.01	-0.01	-0.00	-0.34	-0.02	-0.01	-0.01	-0.00	-0.00	-0.01	-0.01	-0.01	-0.00	-0.01
0.09	1.00	0.11	0.07	0.04	0.02	-0.13	-0.35	-0.05	-0.01	-0.01	-0.01	-0.19	-0.17	-0.02	-0.01	-0.01	-0.01	-0.03	-0.03	-0.02	-0.01	-0.02
0.05	0.11	1.00	0.12	0.07	0.04	-0.08	-0.22	-0.32	-0.02	-0.02	-0.02	-0.11	-0.11	-0.12	-0.02	-0.01	-0.01	-0.18	-0.05	-0.03	-0.02	-0.03
0.03	0.07	0.12	1.00	0.11	0.06	-0.05	-0.14	-0.23	-0.15	-0.03	-0.02	-0.07	-0.07	-0.09	-0.12	-0.02	-0.02	-0.12	-0.33	-0.04	-0.02	-0.05
0.02	0.04	0.07	0.11	1.00	-0.05	-0.03	-0.09	-0.13	-0.09	-0.24	-0.04	-0.04	-0.05	-0.05	-0.08	-0.13	-0.04	-0.07	-0.19	-0.27	-0.04	-0.25
0.01	0.02	0.04	0.06	-0.05	1.00	-0.02	-0.05	-0.08	-0.05	-0.10	-0.28	-0.02	-0.03	-0.03	-0.04	-0.05	-0.26	-0.04	-0.10	-0.12	-0.28	-0.34
-0.25	-0.13	-0.08	-0.05	-0.03	-0.02	1.00	0.06	0.04	0.01	0.01	0.01	0.11	0.03	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01
-0.04	-0.35	-0.22	-0.14	-0.09	-0.05	0.06	1.00	0.10	0.03	0.03	0.02	0.09	0.08	0.04	0.02	0.01	0.02	0.06	0.06	0.03	0.02	0.04
-0.02	-0.05	-0.32	-0.23	-0.13	-0.08	0.04	0.10	1.00	0.05	0.04	0.03	0.05	0.05	0.06	0.04	0.02	0.03	0.08	0.10	0.05	0.03	0.06
-0.01	-0.01	-0.02	-0.15	-0.09	-0.05	0.01	0.03	0.05	1.00	0.03	0.02	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.07	0.03	0.02	0.04
-0.01	-0.01	-0.02	-0.03	-0.24	-0.10	0.01	0.03	0.04	0.03	1.00	0.04	0.01	0.01	0.02	0.02	0.04	0.04	0.02	0.06	0.08	0.04	0.10
-0.00	-0.01	-0.02	-0.02	-0.04	-0.28	0.01	0.02	0.03	0.02	0.04	1.00	0.01	0.01	0.01	0.02	0.02	0.08	0.01	0.04	0.05	0.08	0.11
-0.34	-0.19	-0.11	-0.07	-0.04	-0.02	0.11	0.09	0.05	0.01	0.01	0.01	1.00	0.04	0.02	0.01	0.01	0.01	0.03	0.03	0.02	0.01	0.02
-0.02	-0.17	-0.11	-0.07	-0.05	-0.03	0.03	0.08	0.05	0.01	0.01	0.01	0.04	1.00	0.02	0.01	0.01	0.01	0.03	0.03	0.02	0.01	0.02
-0.01	-0.02	-0.12	-0.09	-0.05	-0.03	0.01	0.04	0.06	0.02	0.02	0.01	0.02	0.02	1.00	0.01	0.01	0.01	0.03	0.04	0.02	0.01	0.02
-0.01	-0.01	-0.02	-0.12	-0.08	-0.04	0.01	0.02	0.04	0.03	0.02	0.02	0.01	0.01	0.01	1.00	0.01	0.01	0.02	0.05	0.03	0.02	0.03
-0.00	-0.01	-0.01	-0.02	-0.13	-0.05	0.01	0.01	0.02	0.02	0.04	0.02	0.01	0.01	0.01	0.01	1.00	0.02	0.01	0.03	0.04	0.02	0.05
-0.00	-0.01	-0.01	-0.02	-0.04	-0.26	0.01	0.02	0.03	0.02	0.04	0.08	0.01	0.01	0.01	0.01	0.02	1.00	0.01	0.04	0.04	0.08	0.10
-0.01	-0.03	-0.18	-0.12	-0.07	-0.04	0.02	0.06	0.08	0.02	0.02	0.01	0.03	0.03	0.03	0.02	0.01	0.01	1.00	0.05	0.03	0.02	0.03
-0.01	-0.03	-0.05	-0.33	-0.19	-0.10	0.02	0.06	0.10	0.07	0.06	0.04	0.03	0.03	0.04	0.05	0.03	0.04	0.05	1.00	0.07	0.04	0.09
-0.01	-0.02	-0.03	-0.04	-0.27	-0.12	0.01	0.03	0.05	0.03	0.08	0.05	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.07	1.00	0.05	0.12
-0.00	-0.01	-0.02	-0.02	-0.04	-0.28	0.01	0.02	0.03	0.02	0.04	0.08	0.01	0.01	0.01	0.02	0.02	0.08	0.02	0.04	0.05	1.00	0.11
-0.01	-0.02	-0.03	-0.05	-0.25	-0.34	0.01	0.04	0.06	0.04	0.10	0.11	0.02	0.02	0.02	0.03	0.05	0.10	0.03	0.09	0.12	0.11	1.00

CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)



SYMBOLS:	=	LARGE NEGATIVE CORRELATION	whenever	-1 <= R <	-L
	-	MODERATE NEGATIVE CORRELATION	whenever	-L <= R <	-M
	.	SMALL CORRELATION	whenever	-M <= R <=	+M
	+	MODERATE POSITIVE CORRELATION	whenever	+M < R <=	+L
	*	LARGE POSITIVE CORRELATION	whenever	+L < R <=	+1

Where R is the estimated correlation, M is 0.2 and L is 0.5

SUMMMARY OF RESIDUALS

Index 1 RV SPR 1
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-0.3297	0.1600	0.0000	0.0000	0.0000	27710.082
1979	-0.1833	-0.0045	0.0000	0.0000	0.0000	23507.343
1980	-2.5956	-0.1615	0.0000	0.0000	0.0000	20090.897
1981	1.4830	0.5609	0.0000	0.0000	0.0000	41376.404
1982	-0.0688	-0.3018	0.0283	0.0066	0.1258	17461.007
1983	-0.4626	-0.9012	0.0400	0.0175	0.3347	9589.302
1984	-0.2615	0.1435	0.0490	-0.0198	-0.3786	27257.725
1985	-1.6742	-1.0219	0.0566	-0.0369	-0.7041	8499.047
1986	0.5105	0.5851	0.0632	-0.0047	-0.0901	42391.173
1987	-2.7328	-0.3952	0.0693	-0.1619	-3.0904	15905.346
1988	0.2919	-0.0740	0.0748	0.0274	0.5225	21929.004
1989	-0.3190	-0.2023	0.0800	-0.0093	-0.1782	19289.306
1990	-0.9895	-1.0463	0.0848	0.0048	0.0919	8293.989
1991	0.7145	-0.2544	0.0894	0.0867	1.6536	18309.081
1992	-1.4470	-1.9756	0.0894	0.0473	0.9023	3274.566

Partial variance for this index is 0.002855

Index 2 RV SPR 2
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-2.0087	-1.5450	0.0000	0.0000	0.0000	4267.652
1979	-0.0266	0.1257	0.0000	0.0000	0.0000	22685.286
1980	0.4845	-0.0403	0.0000	0.0000	0.0000	19215.421
1981	0.3173	-0.2007	0.0000	0.0000	0.0000	16368.505
1982	0.8892	0.5259	0.0896	0.0325	0.6211	33851.704
1983	0.3435	-0.3572	0.1267	0.0888	1.6940	13996.362
1984	-1.1058	-0.9479	0.1552	-0.0245	-0.4676	7753.334
1985	0.6350	0.1060	0.1792	0.0948	1.8086	22243.446
1986	-1.1935	-1.0737	0.2003	-0.0240	-0.4581	6837.183
1987	0.1443	0.5468	0.2194	-0.0883	-1.6853	34565.803
1988	-0.7129	-0.4312	0.2370	-0.0668	-1.2742	12998.670
1989	-0.0447	-0.1087	0.2534	0.0162	0.3096	17944.902
1990	-0.4101	-0.2365	0.2687	-0.0467	-0.8905	15792.747
1991	-1.0043	-1.0814	0.2833	0.0219	0.4172	6784.210
1992	-0.1060	-0.2918	0.2833	0.0526	1.0044	14943.156

Partial variance for this index is 0.002715

Index 3 RV SPR 3
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	1.1460	0.5025	0.0000	0.0000	0.0000	25523.985
1979	-1.7751	-1.5934	0.0000	0.0000	0.0000	3138.457
1980	0.4245	0.0827	0.0000	0.0000	0.0000	16773.420
1981	0.4579	-0.2263	0.0000	0.0000	0.0000	12314.685
1982	-0.2234	-0.3856	0.1111	0.0180	0.3438	10501.395
1983	0.5503	0.2306	0.1571	0.0502	0.9584	19447.027
1984	-0.7910	-0.7114	0.1924	-0.0153	-0.2919	7581.119
1985	-0.8426	-1.0951	0.2222	0.0561	1.0704	5165.270
1986	0.0368	-0.2197	0.2484	0.0637	1.2154	12396.908
1987	-1.4731	-1.2559	0.2721	-0.0591	-1.1273	4397.997
1988	0.5720	0.3327	0.2939	0.0703	1.3417	21538.236
1989	-0.8619	-0.5162	0.3142	-0.1086	-2.0722	9215.482
1990	-0.0294	-0.1874	0.3332	0.0527	1.0049	12802.742
1991	-0.7792	-0.6019	0.3513	-0.0623	-1.1881	8458.301
1992	-1.3193	-1.3081	0.3513	-0.0039	-0.0750	4174.564

Partial variance for this index is 0.002724

Index 4 RV SPR 4
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	0.0521	0.1047	0.0000	0.0000	0.0000	7945.953
1979	0.7323	0.6630	0.0000	0.0000	0.0000	13886.591
1980	-1.4814	-1.4054	0.0000	0.0000	0.0000	1755.197
1981	0.5952	0.1674	0.0000	0.0000	0.0000	8459.522
1982	0.3426	-0.1333	0.0458	0.0218	0.4160	6263.092
1983	-0.1828	-0.3313	0.0648	0.0096	0.1837	5137.716
1984	0.2328	0.1869	0.0793	0.0036	0.0696	8626.175
1985	0.1403	-0.8334	0.0916	0.0892	1.7024	3109.637
1986	-0.9378	-1.2656	0.1024	0.0336	0.6408	2018.448
1987	-0.2011	-0.1742	0.1122	-0.0030	-0.0577	6011.908
1988	-0.8004	-1.1227	0.1212	0.0391	0.7453	2328.574
1989	0.5103	0.3715	0.1296	0.0180	0.3432	10375.410
1990	-0.3430	-0.3785	0.1374	0.0049	0.0930	4901.064
1991	-0.0403	-0.1896	0.1449	0.0216	0.4128	5919.809
1992	-1.7301	-0.5840	0.1449	-0.1660	-3.1685	3990.683

Partial variance for this index is 0.002901

Index 5 RV SPR 5
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	0.2042	-0.1325	0.0000	0.0000	0.0000	2877.463
1979	-0.1591	0.2971	0.0000	0.0000	0.0000	4421.756
1980	0.8481	0.7512	0.0000	0.0000	0.0000	6962.821
1981	-1.8497	-1.2049	0.0000	0.0000	0.0000	984.615
1982	0.4928	0.3574	0.0573	0.0078	0.1481	4696.552
1983	0.0942	-0.2316	0.0811	0.0264	0.5039	2606.005
1984	-0.3524	-0.5042	0.0993	0.0151	0.2876	1984.126
1985	0.7383	0.2078	0.1146	0.0608	1.1605	4043.977
1986	-0.1523	-0.9208	0.1282	0.0985	1.8796	1308.138
1987	-2.3587	-1.2604	0.1404	-0.1542	-2.9426	931.410
1988	0.0162	-0.0898	0.1517	0.0161	0.3066	3002.974
1989	-1.0258	-1.1987	0.1621	0.0280	0.5346	990.780
1990	0.3447	0.3656	0.1720	-0.0036	-0.0686	4735.068
1991	-0.3121	-0.3523	0.1813	0.0073	0.1389	2309.748
1992	-0.8547	-0.5592	0.1813	-0.0536	-1.0220	1877.958

Partial variance for this index is 0.003088

Index 6 RV SPR 6
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-0.8002	-0.2258	0.0000	0.0000	0.0000	1124.160
1979	-0.3113	0.1302	0.0000	0.0000	0.0000	1604.853
1980	0.6261	0.5829	0.0000	0.0000	0.0000	2523.565
1981	1.0019	0.9415	0.0000	0.0000	0.0000	3612.311
1982	-2.9927	-0.8645	0.0508	-0.1081	-2.0624	593.498
1983	0.2984	0.3679	0.0718	-0.0050	-0.0953	2035.536
1984	0.2838	-0.1781	0.0880	0.0406	0.7754	1179.013
1985	-0.1682	-0.4885	0.1016	0.0325	0.6208	864.401
1986	0.6838	0.1305	0.1136	0.0628	1.1990	1605.310
1987	-0.5793	-0.7943	0.1244	0.0267	0.5104	636.691
1988	-1.9600	-1.0159	0.1344	-0.1268	-2.4206	510.124
1989	0.0753	-0.2438	0.1436	0.0458	0.8746	1104.085
1990	-0.9398	-1.0129	0.1524	0.0111	0.2125	511.681
1991	0.0497	0.2605	0.1606	-0.0339	-0.6460	1828.194
1992	-0.7968	-0.9018	0.1606	0.0169	0.3216	571.808

Partial variance for this index is 0.002845

Index 7 RV FAL 1
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-0.8147	0.2550	0.0000	0.0000	0.0000	27710.082
1979	0.1446	0.0905	0.0000	0.0000	0.0000	23507.343
1980	-1.0625	-0.0666	0.0000	0.0000	0.0000	20090.897
1981	-0.2019	0.6559	0.0000	0.0000	0.0000	41376.404
1982	-0.2703	-0.2069	0.0404	-0.0026	-0.0489	17461.007
1983	-0.0681	-0.8062	0.0571	0.0422	0.8047	9589.302
1984	1.1026	0.2385	0.0700	0.0605	1.1539	27257.725
1985	-0.6120	-0.9269	0.0808	0.0254	0.4855	8499.047
1986	1.1526	0.6801	0.0903	0.0427	0.8145	42391.173
1987	-1.2715	-0.3002	0.0990	-0.0961	-1.8343	15905.346
1988	-0.5177	0.0210	0.1069	-0.0576	-1.0988	21929.004
1989	0.4723	-0.1073	0.1143	0.0662	1.2638	19289.306
1990	-0.2664	-0.9513	0.1212	0.0830	1.5841	8293.989
1991	-0.7833	-0.1594	0.1278	-0.0797	-1.5209	18309.081
1992	-2.1397	-1.8806	0.1278	-0.0331	-0.6316	3274.566

Partial variance for this index is 0.002872

Index 8 RV FAL 2
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-1.6987	-1.6751	0.0000	0.0000	0.0000	4267.652
1979	0.3603	-0.0044	0.0000	0.0000	0.0000	22685.286
1980	0.2246	-0.1704	0.0000	0.0000	0.0000	19215.421
1981	-0.4579	-0.3308	0.0000	0.0000	0.0000	16368.505
1982	1.0024	0.3958	0.0418	0.0253	0.4834	33851.704
1983	-0.3908	-0.4874	0.0591	0.0057	0.1089	13996.362
1984	-0.6922	-1.0780	0.0723	0.0279	0.5326	7753.334
1985	0.6573	-0.0241	0.0835	0.0569	1.0862	22243.446
1986	-1.7716	-1.2038	0.0934	-0.0530	-1.0119	6837.183
1987	0.5667	0.4167	0.1023	0.0154	0.2929	34565.803
1988	-1.1393	-0.5613	0.1105	-0.0639	-1.2189	12998.670
1989	-0.3595	-0.2388	0.1181	-0.0142	-0.2719	17944.902
1990	0.7498	-0.3666	0.1253	0.1399	2.6696	15792.747
1991	-1.2740	-1.2116	0.1321	-0.0083	-0.1575	6784.210
1992	-1.1375	-0.4219	0.1321	-0.0945	-1.8037	14943.156

Partial variance for this index is 0.002975

Index 9 RV FAL 3
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	1.1113	0.3931	0.0000	0.0000	0.0000	25523.985
1979	-1.4854	-1.7028	0.0000	0.0000	0.0000	3138.457
1980	0.4211	-0.0267	0.0000	0.0000	0.0000	16773.420
1981	-0.6913	-0.3357	0.0000	0.0000	0.0000	12314.685
1982	0.6917	-0.4950	0.0387	0.0460	0.8772	10501.395
1983	0.6195	0.1212	0.0548	0.0273	0.5209	19447.027
1984	-0.0978	-0.8209	0.0671	0.0485	0.9257	7581.119
1985	-2.4080	-1.2046	0.0775	-0.0932	-1.7791	5165.270
1986	-0.3388	-0.3291	0.0866	-0.0008	-0.0160	12396.908
1987	-1.9967	-1.3654	0.0949	-0.0599	-1.1430	4397.997
1988	0.1830	0.2233	0.1025	-0.0041	-0.0789	21538.236
1989	-0.9564	-0.6257	0.1096	-0.0362	-0.6914	9215.482
1990	-0.0896	-0.2969	0.1162	0.0241	0.4595	12802.742
1991	0.3086	-0.7114	0.1225	0.1249	2.3843	8458.301
1992	-1.9015	-1.4175	0.1225	-0.0593	-1.1314	4174.564

Partial variance for this index is 0.002823

Index 10 RV FAL 4
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-0.1686	-0.2737	0.0000	0.0000	0.0000	7945.953
1979	1.6150	0.2846	0.0000	0.0000	0.0000	13886.591
1980	-1.3102	-1.7837	0.0000	0.0000	0.0000	1755.197
1981	-0.0717	-0.2110	0.0000	0.0000	0.0000	8459.522
1982	0.6286	-0.5116	0.0374	0.0426	0.8128	6263.092
1983	-1.3297	-0.7097	0.0528	-0.0328	-0.6251	5137.716
1984	-0.0441	-0.1915	0.0647	0.0095	0.1820	8626.175
1985	0.0636	-1.2118	0.0747	0.0953	1.8184	3109.637
1986	-2.0885	-1.6440	0.0835	-0.0371	-0.7085	2018.448
1987	-0.7778	-0.5526	0.0915	-0.0206	-0.3932	6011.908
1988	-2.0047	-1.5011	0.0988	-0.0498	-0.9498	2328.574
1989	0.0892	-0.0069	0.1057	0.0101	0.1936	10375.410
1990	-1.5122	-0.7569	0.1121	-0.0846	-1.6152	4901.064
1991	0.3362	-0.5680	0.1181	0.1068	2.0382	5919.809
1992	-1.0981	-0.9624	0.1181	-0.0160	-0.3060	3990.683

Partial variance for this index is 0.002585

Index 11 RV FAL 5
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-0.4015	-0.8924	0.0000	0.0000	0.0000	2877.463
1979	0.9423	-0.4627	0.0000	0.0000	0.0000	4421.756
1980	1.4574	-0.0087	0.0000	0.0000	0.0000	6962.821
1981	-1.5924	-1.9648	0.0000	0.0000	0.0000	984.615
1982	0.4500	-0.4024	0.0300	0.0256	0.4879	4696.552
1983	-1.6997	-0.9914	0.0424	-0.0300	-0.5733	2606.005
1984	-1.9285	-1.2641	0.0520	-0.0345	-0.6587	1984.126
1985	0.8405	-0.5520	0.0600	0.0835	1.5941	4043.977
1986	-1.1836	-1.6807	0.0671	0.0333	0.6362	1308.138
1987	-3.6260	-2.0203	0.0735	-0.1180	-2.2511	931.410
1988	-0.6555	-0.8497	0.0794	0.0154	0.2940	3002.974
1989	-1.4177	-1.9585	0.0848	0.0459	0.8756	990.780
1990	0.2846	-0.3943	0.0900	0.0611	1.1657	4735.068
1991	-0.5883	-1.1121	0.0948	0.0497	0.9481	2309.748
1992	-2.6089	-1.3191	0.0948	-0.1223	-2.3346	1877.958

Partial variance for this index is 0.003537

Index 12 RV FAL 6
Index is tuned to the sum of Jan1 full stock sizes (in number)
for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	0.3326	-0.4425	0.0000	0.0000	0.0000	1124.160
1979	0.9897	-0.0865	0.0000	0.0000	0.0000	1604.853
1980	0.8645	0.3662	0.0000	0.0000	0.0000	2523.565
1981	0.7020	0.7248	0.0000	0.0000	0.0000	3612.311
1982	-0.8319	-1.0812	0.0479	0.0119	0.2278	593.498
1983	-0.2533	0.1512	0.0677	-0.0274	-0.5226	2035.536
1984	-0.9792	-0.3948	0.0829	-0.0485	-0.9247	1179.013
1985	-1.9825	-0.7052	0.0958	-0.1223	-2.3338	864.401
1986	-0.2100	-0.0862	0.1071	-0.0132	-0.2528	1605.310
1987	-0.7142	-1.0110	0.1173	0.0348	0.6641	636.691
1988	-1.4929	-1.2326	0.1267	-0.0330	-0.6291	510.124
1989	0.3567	-0.4605	0.1354	0.1107	2.1117	1104.085
1990	-0.8123	-1.2296	0.1436	0.0599	1.1436	511.681
1991	0.1541	0.0438	0.1514	0.0167	0.3187	1828.194
1992	-1.4499	-1.1185	0.1514	-0.0502	-0.9575	571.808

Partial variance for this index is 0.00288

Index 13 CM CPE 2
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-1.3539	-1.5118	0.0000	0.0000	0.0000	3674.180
1979	-0.2187	0.1614	0.0000	0.0000	0.0000	19580.835
1980	0.2577	-0.0716	0.0000	0.0000	0.0000	15510.036
1981	0.2284	-0.2315	0.0000	0.0000	0.0000	13218.649
1982	1.1433	0.4445	0.0640	0.0447	0.8528	25987.377
1983	0.1310	-0.4653	0.0904	0.0539	1.0291	10462.991
1984	-0.9007	-0.9612	0.1108	0.0067	0.1279	6371.944
1985	0.1883	0.0108	0.1279	0.0227	0.4333	16843.196
1986	-1.0039	-1.1033	0.1430	0.0142	0.2712	5528.193
1987	0.4425	0.5025	0.1567	-0.0094	-0.1794	27540.383
1988	-0.9032	-0.4153	0.1692	-0.0825	-1.5752	10998.850
1989	-0.6524	-0.0899	0.1809	-0.1017	-1.9416	15229.410
1990	0.3017	-0.3496	0.1919	0.1250	2.3844	11746.344
1991	-1.2181	-1.1315	0.2022	-0.0175	-0.3343	5374.199

Partial variance for this index is 0.003071

Index 14 CM CPE 3
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	1.2401	0.5546	0.0000	0.0000	0.0000	19118.599
1979	-1.5160	-1.5289	0.0000	0.0000	0.0000	2380.211
1980	0.4500	0.1009	0.0000	0.0000	0.0000	12145.893
1981	0.1371	-0.2044	0.0000	0.0000	0.0000	8950.492
1982	-0.2728	-0.3808	0.1291	0.0140	0.2662	7502.704
1983	0.3239	0.1925	0.1826	0.0240	0.4576	13311.532
1984	-0.2104	-0.7832	0.2236	0.1281	2.4437	5017.626
1985	-1.0920	-1.1874	0.2582	0.0247	0.4704	3349.007
1986	-0.1576	-0.2188	0.2887	0.0177	0.3371	8822.657
1987	-1.6179	-1.2161	0.3162	-0.1270	-2.4241	3254.357
1988	0.2767	0.3307	0.3415	-0.0184	-0.3516	15283.352
1989	-0.5108	-0.4744	0.3651	-0.0133	-0.2539	6832.745
1990	-0.2968	-0.2075	0.3873	-0.0346	-0.6604	8923.169
1991	-0.5025	-0.6132	0.4082	0.0452	0.8622	5947.420

Partial variance for this index is 0.003003

Index 15 CM CPE 4
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	0.6601	0.1538	0.0000	0.0000	0.0000	6012.697
1979	1.1289	0.6655	0.0000	0.0000	0.0000	10029.522
1980	-1.6772	-1.3526	0.0000	0.0000	0.0000	1332.989
1981	0.1991	0.2154	0.0000	0.0000	0.0000	6394.562
1982	0.0182	-0.2120	0.0962	0.0221	0.4226	4170.683
1983	-0.4993	-0.4417	0.1361	-0.0078	-0.1496	3314.579
1984	0.3532	0.1598	0.1667	0.0322	0.6154	6048.527
1985	-0.8646	-0.9074	0.1925	0.0082	0.1572	2080.490
1986	-1.5142	-1.2996	0.2152	-0.0462	-0.8814	1405.559
1987	-0.4040	-0.1734	0.2357	-0.0544	-1.0377	4334.771
1988	-1.1575	-1.1918	0.2546	0.0087	0.1668	1565.552
1989	0.3674	0.3327	0.2722	0.0094	0.1801	7190.256
1990	-0.5739	-0.4033	0.2887	-0.0493	-0.9400	3444.461
1991	-0.1206	-0.3815	0.3043	0.0794	1.5148	3520.411

Partial variance for this index is 0.001237

Index 16 CM CPE 5
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	0.4481	-0.0692	0.0000	0.0000	0.0000	2179.586
1979	0.3722	0.3709	0.0000	0.0000	0.0000	3384.403
1980	0.9603	0.7820	0.0000	0.0000	0.0000	5105.640
1981	-2.0163	-1.1063	0.0000	0.0000	0.0000	772.627
1982	0.4780	0.3094	0.0794	0.0134	0.2553	3182.769
1983	-0.1252	-0.2610	0.1123	0.0152	0.2909	1799.166
1984	-0.6752	-0.5500	0.1375	-0.0172	-0.3284	1347.610
1985	0.2286	0.1223	0.1588	0.0169	0.3221	2639.502
1986	-1.0123	-0.9182	0.1775	-0.0167	-0.3186	932.467
1987	-1.6472	-1.2053	0.1944	-0.0859	-1.6393	699.758
1988	0.0400	-0.2076	0.2100	0.0520	0.9925	1897.777
1989	-1.6320	-1.1698	0.2245	-0.1038	-1.9802	725.038
1990	0.3232	0.2683	0.2381	0.0131	0.2493	3054.506
1991	-0.2191	-0.6293	0.2510	0.1030	1.9647	1244.862

Partial variance for this index is 0.002601

Index 17 CM CPE 6
Index is tuned to the sum of mean full stock sizes (in number)
for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1978	-1.2932	-0.1168	0.0000	0.0000	0.0000	953.948
1979	0.2839	0.1279	0.0000	0.0000	0.0000	1218.351
1980	1.0007	0.4665	0.0000	0.0000	0.0000	1709.348
1981	1.0282	0.8576	0.0000	0.0000	0.0000	2527.551
1982	-1.1709	-1.0251	0.1584	-0.0231	-0.4407	384.619
1983	0.4331	0.2908	0.2240	0.0319	0.6085	1433.903
1984	-0.1898	-0.3048	0.2744	0.0316	0.6021	790.462
1985	-0.6714	-0.6522	0.3168	-0.0061	-0.1155	558.438
1986	-0.0852	0.0454	0.3542	-0.0463	-0.8829	1121.953
1987	-1.0041	-0.8838	0.3880	-0.0467	-0.8910	443.008
1988	-1.0500	-1.1813	0.4191	0.0550	1.0499	329.013
1989	-0.3469	-0.4209	0.4480	0.0331	0.6320	703.826
1990	-1.3424	-1.1487	0.4752	-0.0921	-1.7570	339.924
1991	0.0843	-0.0358	0.5009	0.0602	1.1480	1034.395

Partial variance for this index is 0.001828

Standardized residuals by index & yr; with row/column/grand means

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.0000	0.0000	0.0000	0.0000	0.1258	0.3347	-0.3786	-0.7041	-0.0901	-3.0904	0.5225	-0.1782	0.0919	1.6536
2	0.0000	0.0000	0.0000	0.0000	0.6211	1.6940	-0.4676	1.8086	-0.4581	-1.6853	-1.2742	0.3096	-0.8905	0.4172
3	0.0000	0.0000	0.0000	0.0000	0.3438	0.9584	-0.2919	1.0704	1.2154	-1.1273	1.3417	-2.0722	1.0049	-1.1881
4	0.0000	0.0000	0.0000	0.0000	0.4160	0.1837	0.0696	1.7024	0.6408	-0.0577	0.7453	0.3432	0.0930	0.4128
5	0.0000	0.0000	0.0000	0.0000	0.1481	0.5039	0.2876	1.1605	1.8796	-2.9426	0.3066	0.5346	-0.0686	0.1389
6	0.0000	0.0000	0.0000	0.0000	-2.0624	-0.0953	0.7754	0.6208	1.1990	0.5104	-2.4206	0.8746	0.2125	-0.6460
7	0.0000	0.0000	0.0000	0.0000	-0.0489	0.8047	1.1539	0.4855	0.8145	-1.8343	-1.0988	1.2638	1.5841	-1.5209
8	0.0000	0.0000	0.0000	0.0000	0.4834	0.1089	0.5326	1.0862	-1.0119	0.2929	-1.2189	-0.2719	2.6696	-0.1575
9	0.0000	0.0000	0.0000	0.0000	0.8772	0.5209	0.9257	-1.7791	-0.0160	-1.1430	-0.0789	-0.6914	0.4595	2.3843
10	0.0000	0.0000	0.0000	0.0000	0.8128	-0.6251	0.1820	1.8184	-0.7085	-0.3932	-0.9498	0.1936	-1.6152	2.0382
11	0.0000	0.0000	0.0000	0.0000	0.4879	-0.5733	-0.6587	1.5941	0.6362	-2.2511	0.2940	0.8756	1.1657	0.9481
12	0.0000	0.0000	0.0000	0.0000	0.2278	-0.5226	-0.9247	-2.3338	-0.2528	0.6641	-0.6291	2.1117	1.1436	0.3187
13	0.0000	0.0000	0.0000	0.0000	0.8528	1.0291	0.1279	0.4333	0.2712	-0.1794	-1.5752	-1.9416	2.3844	-0.3343
14	0.0000	0.0000	0.0000	0.0000	0.2662	0.4576	2.4437	0.4704	0.3371	-2.4241	-0.3516	-0.2539	-0.6604	0.8622
15	0.0000	0.0000	0.0000	0.0000	0.4226	-0.1496	0.6154	0.1572	-0.8814	-1.0377	0.1668	0.1801	-0.9400	1.5148
16	0.0000	0.0000	0.0000	0.0000	0.2553	0.2909	-0.3284	0.3221	-0.3186	-1.6393	0.9925	-1.9802	0.2493	1.9647
17	0.0000	0.0000	0.0000	0.0000	-0.4407	0.6085	0.6021	-0.1155	-0.8829	-0.8910	1.0499	0.6320	-1.7570	1.1480
**	0.0000	0.0000	0.0000	0.0000	0.2229	0.3253	0.2745	0.4587	0.1396	-1.1311	-0.2457	-0.0042	0.3016	0.5856

	1992********	
1	0.9023	-0.0540
2	1.0044	0.0719
3	-0.0750	0.0787
4	-3.1685	0.0920
5	-1.0220	0.0618
6	0.3216	-0.0473
7	-0.6316	0.0648
8	-1.8037	0.0473
9	-1.1314	0.0219
10	-0.3060	0.0298
11	-2.3346	0.0123
12	-0.9575	-0.0770
13	-99.0000	0.0763
14	-99.0000	0.0820
15	-99.0000	0.0035
16	-99.0000	-0.0137
17	-99.0000	-0.0033
**	-0.7668	0.0208

-99 in the above table indicates a missing value

Percent of total sum of squares by index & yr; with row/column sums

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992*******	
1	0.00	0.00	0.00	0.00	0.01	0.05	0.06	0.22	0.00	4.21	0.12	0.01	0.00	1.20	0.36	6.25
2	0.00	0.00	0.00	0.00	0.17	1.26	0.10	1.44	0.09	1.25	0.72	0.04	0.35	0.08	0.44	5.94
3	0.00	0.00	0.00	0.00	0.05	0.40	0.04	0.50	0.65	0.56	0.79	1.89	0.44	0.62	0.00	5.96
4	0.00	0.00	0.00	0.00	0.08	0.01	0.00	1.28	0.18	0.00	0.24	0.05	0.00	0.08	4.42	6.35
5	0.00	0.00	0.00	0.00	0.01	0.11	0.04	0.59	1.56	3.81	0.04	0.13	0.00	0.01	0.46	6.76
6	0.00	0.00	0.00	0.00	1.87	0.00	0.26	0.17	0.63	0.11	2.58	0.34	0.02	0.18	0.05	6.23
7	0.00	0.00	0.00	0.00	0.00	0.29	0.59	0.10	0.29	1.48	0.53	0.70	1.11	1.02	0.18	6.29
8	0.00	0.00	0.00	0.00	0.10	0.01	0.12	0.52	0.45	0.04	0.65	0.03	3.14	0.01	1.43	6.51
9	0.00	0.00	0.00	0.00	0.34	0.12	0.38	1.39	0.00	0.58	0.00	0.21	0.09	2.50	0.56	6.18
10	0.00	0.00	0.00	0.00	0.29	0.17	0.01	1.46	0.22	0.07	0.40	0.02	1.15	1.83	0.04	5.66
11	0.00	0.00	0.00	0.00	0.10	0.14	0.19	1.12	0.18	2.23	0.04	0.34	0.60	0.40	2.40	7.74
12	0.00	0.00	0.00	0.00	0.02	0.12	0.38	2.40	0.03	0.19	0.17	1.96	0.58	0.04	0.40	6.31
13	0.00	0.00	0.00	0.00	0.32	0.47	0.01	0.08	0.03	0.01	1.09	1.66	2.50	0.05	-99.00	6.23
14	0.00	0.00	0.00	0.00	0.03	0.09	2.63	0.10	0.05	2.59	0.05	0.03	0.19	0.33	-99.00	6.09
15	0.00	0.00	0.00	0.00	0.08	0.01	0.17	0.01	0.34	0.47	0.01	0.01	0.39	1.01	-99.00	2.51
16	0.00	0.00	0.00	0.00	0.03	0.04	0.05	0.05	0.04	1.18	0.43	1.73	0.03	1.70	-99.00	5.28
17	0.00	0.00	0.00	0.00	0.09	0.16	0.16	0.01	0.34	0.35	0.49	0.18	1.36	0.58	-99.00	3.71
**	0.00	0.00	0.00	0.00	3.59	3.47	5.18	11.44	5.10	19.15	8.37	9.33	11.96	11.64	10.75	100.00

-99 in the above table indicates a missing value

Partial variance (and proportion of total) by index

	1	2	3	4	5	6	7	8	9	10	11
**	0.00285489	0.00271454	0.00272410	0.00290082	0.00308795	0.00284483	0.00287181	0.00297483	0.00282318	0.00258451	0.00353651
**	0.06134433	0.05832856	0.05853401	0.06233134	0.06635221	0.06112833	0.06170787	0.06392161	0.06066301	0.05553464	0.07599062

	12	13	14	15	16	17**********
**	0.00288014	0.00307124	0.00300316	0.00123694	0.00260094	0.00182833	0.04653872
**	0.06188704	0.06599322	0.06453041	0.02657875	0.05588776	0.03928630	1.00000000

STOCK NUMBERS (Jan 1) in millions - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	27710.082	23507.343	20090.897	41376.404	17461.007	9589.302	27257.725	8499.047	42391.173	15905.346	21929.004
2	4267.652	22685.286	19215.421	16368.505	33851.704	13996.362	7753.334	22243.446	6837.183	34565.803	12998.670
3	25523.985	3138.457	16773.420	12314.685	10501.395	19447.027	7581.119	5165.270	12396.908	4397.997	21538.236
4	7945.953	13886.591	1755.197	8459.522	6263.092	5137.716	8626.175	3109.637	2018.448	6011.908	2328.574
5	2877.463	4421.756	6962.821	984.615	4696.552	2606.005	1984.126	4043.977	1308.138	931.410	3002.974
6	1124.160	1604.853	2523.565	3612.311	593.498	2035.536	1179.013	864.401	1605.310	636.691	510.124
7	1433.952	801.851	899.527	1092.515	1685.308	231.656	964.402	498.398	334.919	746.983	293.259
8	67.152	861.852	586.827	333.817	517.158	770.858	103.704	375.170	210.799	195.488	367.272
9	146.028	12.452	476.700	401.733	162.012	230.683	418.489	45.093	123.482	107.439	103.047
10	54.343	148.099	28.267	189.879	187.026	148.094	292.713	205.481	75.381	67.190	95.490
1+	71150.769	71068.538	69312.642	85133.986	75918.752	54193.239	56160.799	45049.919	67301.739	63566.254	63166.650

	1989	1990	1991	1992
1	19289.306	8293.989	18309.081	3274.566
2	17944.902	15792.747	6784.210	14943.156
3	9215.482	12802.742	8458.301	4174.564
4	10375.410	4901.064	5919.809	3990.683
5	990.780	4735.068	2309.748	1877.958
6	1104.085	511.681	1828.194	571.808
7	196.874	414.432	211.721	512.335
8	94.421	86.990	117.623	59.333
9	122.444	38.398	38.647	32.963
10	43.573	84.744	37.916	21.456
1+	59377.277	47661.854	44015.250	29458.824

Summaries for ages 2 8 3 8 4 8 5 8 6 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	43240.317	47400.644	48716.777	43165.970	58108.707	44225.160	28191.872	36300.299	24711.704	47486.279	41039.109
3	38972.665	24715.358	29501.356	26797.465	24257.003	30228.798	20438.538	14056.854	17874.521	12920.477	28040.439
4	13448.681	21576.901	12727.936	14482.780	13755.609	10781.771	12857.419	8891.583	5477.613	8522.480	6502.204
5	5502.727	7690.311	10972.739	6023.258	7492.516	5644.055	4231.245	5781.946	3459.165	2510.572	4173.629
6	2625.264	3268.555	4009.918	5038.643	2795.965	3038.050	2247.119	1737.969	2151.028	1579.161	1170.656

	1989	1990	1991	1992
2	39921.955	39244.724	25629.605	26129.838
3	21977.053	23451.977	18845.395	11186.682
4	12761.571	10649.234	10387.094	7012.118
5	2386.161	5748.171	4467.285	3021.435
6	1395.381	1013.103	2157.537	1143.477

FISHING MORTALITY - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.0001	0.0016	0.0049	0.0007	0.0212	0.0125	0.0033	0.0176	0.0041	0.0018	0.0005	0.0000	0.0009	0.0031
2	0.1073	0.1019	0.2449	0.2439	0.3543	0.4131	0.2062	0.3846	0.2412	0.2730	0.1440	0.1376	0.4244	0.2856
3	0.4087	0.3811	0.4845	0.4761	0.5149	0.6129	0.6912	0.7396	0.5237	0.4359	0.5304	0.4314	0.5714	0.5512
4	0.3861	0.4903	0.3781	0.3885	0.6769	0.7514	0.5576	0.6659	0.5734	0.4941	0.6545	0.5844	0.5523	0.9481
5	0.3839	0.3609	0.4562	0.3062	0.6361	0.5931	0.6309	0.7239	0.5201	0.4020	0.8006	0.4608	0.7517	1.1961
6	0.1379	0.3789	0.6372	0.5624	0.7408	0.5470	0.6610	0.7481	0.5650	0.5752	0.7521	0.7799	0.6824	1.0721
7	0.3091	0.1122	0.7913	0.5479	0.5822	0.6037	0.7441	0.6605	0.3384	0.5099	0.9333	0.6168	1.0594	1.0721
8	1.4851	0.3922	0.1789	0.5229	0.6073	0.4109	0.6328	0.9113	0.4740	0.4403	0.8984	0.6998	0.6113	1.0721
9	0.3606	0.4385	0.4897	0.4426	0.6623	0.6522	0.6007	0.7230	0.5459	0.4957	0.7684	0.6002	0.6720	1.0721
10	0.3606	0.4385	0.4897	0.4426	0.6623	0.6522	0.6007	0.7230	0.5459	0.4957	0.7684	0.6002	0.6720	1.0721

Avg F for ages 2 8 3 8 4 8 5 8 6 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	0.4597	0.3168	0.4530	0.4354	0.5875	0.5617	0.5891	0.6906	0.4623	0.4472	0.6733	0.5301	0.6647	0.8853
3	0.5185	0.3526	0.4877	0.4673	0.6264	0.5865	0.6529	0.7416	0.4991	0.4763	0.7616	0.5955	0.7048	0.9853
4	0.5404	0.3469	0.4883	0.4656	0.6486	0.5812	0.6453	0.7419	0.4942	0.4843	0.8078	0.6283	0.7314	1.0721
5	0.5790	0.3110	0.5159	0.4849	0.6416	0.5387	0.6672	0.7610	0.4744	0.4819	0.8461	0.6393	0.7762	1.1031
6	0.6440	0.2944	0.5358	0.5444	0.6434	0.5205	0.6793	0.7733	0.4591	0.5085	0.8613	0.6988	0.7844	1.0721

Avg F (weighted by N) for ages 2 8 3 8 4 8 5 8 6 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	0.3645	0.2732	0.3920	0.3764	0.4537	0.5580	0.5130	0.5149	0.4492	0.3271	0.4437	0.3511	0.5383	0.6745
3	0.3926	0.4304	0.4878	0.4573	0.5923	0.6251	0.6294	0.7211	0.5287	0.4718	0.5827	0.5253	0.6150	0.8146
4	0.3622	0.4375	0.4922	0.4414	0.6515	0.6471	0.5930	0.7103	0.5400	0.4903	0.7560	0.5931	0.6674	1.0290
5	0.3276	0.3422	0.5105	0.5157	0.6303	0.5520	0.6651	0.7342	0.5205	0.4810	0.8126	0.6308	0.7656	1.1362
6	0.2659	0.3170	0.6047	0.5566	0.6205	0.5168	0.6954	0.7582	0.5208	0.5276	0.8434	0.7514	0.8305	1.0721

Avg F (wt by catch) for ages 2 8 3 8 4 8 5 8 6 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	0.3909	0.3743	0.4311	0.4063	0.4808	0.5754	0.5779	0.5551	0.4822	0.3476	0.5392	0.4558	0.5572	0.7835
3	0.4006	0.4440	0.4997	0.4650	0.5990	0.6302	0.6343	0.7229	0.5303	0.4745	0.5952	0.5380	0.6249	0.8654
4	0.3836	0.4522	0.5198	0.4548	0.6530	0.6605	0.5968	0.7129	0.5451	0.4927	0.7623	0.5985	0.6828	1.0346
5	0.3792	0.3594	0.5379	0.5298	0.6320	0.5572	0.6672	0.7365	0.5272	0.4891	0.8143	0.6571	0.7713	1.1380
6	0.3719	0.3571	0.6550	0.5568	0.6250	0.5229	0.6972	0.7650	0.5316	0.5306	0.8484	0.7546	0.8585	1.0721

BACKCALCULATED PARTIAL RECRUITMENT

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.00	0.00	0.01	0.00	0.03	0.02	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2	0.07	0.21	0.31	0.43	0.48	0.55	0.28	0.42	0.42	0.47	0.15	0.18	0.40	0.24
3	0.28	0.78	0.61	0.85	0.70	0.82	0.93	0.81	0.91	0.76	0.57	0.55	0.54	0.46
4	0.26	1.00	0.48	0.69	0.91	1.00	0.75	0.73	1.00	0.86	0.70	0.75	0.52	0.79
5	0.26	0.74	0.58	0.54	0.86	0.79	0.85	0.79	0.91	0.70	0.86	0.59	0.71	1.00
6	0.09	0.77	0.81	1.00	1.00	0.73	0.89	0.82	0.99	1.00	0.81	1.00	0.64	0.90
7	0.21	0.23	1.00	0.97	0.79	0.80	1.00	0.72	0.59	0.89	1.00	0.79	1.00	0.90
8	1.00	0.80	0.23	0.93	0.82	0.55	0.85	1.00	0.83	0.77	0.96	0.90	0.58	0.90
9	0.24	0.89	0.62	0.79	0.89	0.87	0.81	0.79	0.95	0.86	0.82	0.77	0.63	0.90
10	0.24	0.89	0.62	0.79	0.89	0.87	0.81	0.79	0.95	0.86	0.82	0.77	0.63	0.90

CATCH BIOMASS (MT)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	1.416	30.277	74.534	23.854	253.727	105.065	85.440	121.776	145.176	18.908	7.873
2	516.611	2981.575	5546.144	4818.954	12908.497	6440.741	2147.858	9185.660	1966.981	11136.365	2406.795
3	19229.452	1949.610	14523.487	10048.603	10291.398	19392.863	8499.962	5167.066	11306.286	3539.287	19122.420
4	8053.832	20709.133	1848.614	8483.059	10823.195	8241.643	12205.050	5385.054	2949.689	8968.470	3597.665
5	3627.903	5969.767	13154.020	1233.353	10834.917	4948.415	4321.579	9720.071	2717.196	1634.551	8205.918
6	761.105	3313.765	7271.366	10266.016	1855.104	5014.371	3439.243	2678.900	4558.633	1968.816	1644.784
7	2561.384	709.594	3788.684	3610.104	6372.786	765.431	4137.444	1787.442	781.274	2440.761	1437.046
8	409.379	2630.591	794.422	1228.833	2132.848	2437.785	449.990	2112.629	723.611	636.497	1999.907
9	475.019	47.216	1421.969	1858.749	898.952	1136.728	1955.330	243.052	602.697	438.034	565.170
10	198.000	606.000	154.000	1151.030	1388.009	946.010	1858.076	1308.918	409.016	360.000	719.006
1+	35834.101	38947.526	48577.239	42722.555	57759.433	49429.053	39099.972	37710.569	26160.557	31141.689	39706.584

	1989	1990	1991
1	0.001	5.827	58.028
2	3389.680	7776.876	2497.129
3	6688.716	12552.014	8352.684
4	15851.042	6700.337	11415.169
5	1802.757	11231.900	7100.882
6	3674.261	1469.097	6532.998
7	682.236	2111.251	951.663
8	466.992	387.860	750.600
9	590.040	216.602	227.074
10	307.998	551.988	353.579
1+	33453.723	43003.752	38239.806

Summaries for ages 2 8 3 8 4 8 5 8 6 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
2	35159.666	38264.033	46926.736	39688.922	55218.745	47241.251	35201.126	36036.823	25003.669	30324.747	38414.535
3	34643.055	35282.459	41380.593	34869.968	42310.248	40800.510	33053.268	26851.163	23036.688	19188.382	36007.740
4	15413.603	33332.849	26857.106	24821.365	32018.850	21407.647	24553.305	21684.097	11730.402	15649.095	16885.320
5	7359.771	12623.716	25008.493	16338.306	21195.655	13166.004	12348.255	16299.043	8780.712	6680.625	13287.655
6	3731.869	6653.950	11854.472	15104.953	10360.738	8217.588	8026.676	6578.972	6063.517	5046.074	5081.737

	1989	1990	1991
2	32555.685	42229.336	37601.126
3	29166.004	34452.460	35103.996
4	22477.288	21900.445	26751.312
5	6626.246	15200.108	15336.143
6	4823.489	3968.208	8235.261

MEAN BIOMASS (MT)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	17755.570	18926.211	15186.929	33064.658	11983.633	8388.301	25972.980	6927.672	35622.969	10456.693
2	4813.175	29253.768	22644.653	19761.880	36434.303	15589.857	10418.128	23883.652	8154.085	40787.307
3	47050.873	5115.073	29976.064	21105.261	19987.203	31641.512	12298.202	6986.028	21589.041	8119.620
4	20858.046	42234.315	4889.405	21837.430	15990.399	10967.941	21889.618	8086.864	5144.347	18149.687
5	9450.686	16542.961	28831.549	4027.707	17034.181	8342.731	6849.901	13427.146	5224.613	4065.592
6	5520.494	8745.324	11411.610	18253.971	2504.253	9166.940	5202.821	3580.705	8067.961	3422.676
7	8286.416	6324.827	4788.079	6589.122	10946.055	1267.878	5560.121	2706.223	2308.785	4786.371
8	275.665	6707.360	4439.511	2349.916	3511.991	5933.446	711.090	2318.288	1526.673	1445.557
9	1317.371	107.670	2903.958	4199.680	1357.342	1742.991	3254.936	336.192	1104.131	883.579
10	549.114	1381.917	314.500	2600.651	2095.776	1450.555	3093.042	1810.511	749.311	726.173
1+	115877.410	135339.428	125386.260	133790.276	121845.136	94492.152	95250.839	70063.281	89491.917	92843.257

	1988	1989	1990	1991
1	15618.157	14143.576	6243.998	18458.063
2	16718.252	24625.956	18324.296	8743.822
3	36053.428	15503.499	21968.843	15154.026
4	5496.654	27121.644	12131.391	12039.804
5	10249.892	3912.306	14942.642	5936.748
6	2186.952	4711.409	2152.739	6093.621
7	1539.767	1106.146	1992.826	887.659
8	2225.955	667.351	634.469	700.118
9	735.514	983.077	322.339	211.802
10	935.716	513.162	821.451	329.799
1+	91760.286	93288.126	79534.995	68555.462

Summaries for ages 2 8 3 8 4 8 5 8 6 8

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
2	96255.355	114923.629	106980.873	93925.287	106408.385	82910.305	62929.881	60988.906	52015.505	80776.811
3	91442.180	85669.861	84336.220	74163.407	69974.081	67320.448	52511.753	37105.254	43861.420	39989.504
4	44391.308	80554.788	54360.156	53058.146	49986.879	35678.936	40213.551	30119.226	22272.379	31869.884
5	23533.262	38320.472	49470.750	31220.717	33996.479	24710.995	18323.933	22032.362	17128.032	13720.197
6	14082.576	21777.511	20639.201	27193.010	16962.299	16368.264	11474.032	8605.216	11903.419	9654.605

	1988	1989	1990	1991
2	74470.900	77648.312	72147.207	49555.798
3	57752.648	53022.355	53822.910	40811.977
4	21699.220	37518.856	31854.067	25657.951
5	16202.566	10397.212	19722.676	13618.147
6	5952.673	6484.906	4780.034	7681.398

SSB AT THE START OF THE SPAWNING SEASON - males & females (MT)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	912.440	1103.780	849.672	1959.513	1199.222	900.356	3108.278	757.838	6933.857	1774.777	2673.066
2	1409.960	7537.894	6911.069	5778.009	16130.857	6340.853	4290.913	11588.547	4702.333	23980.914	8252.152
3	33841.551	3728.131	22413.425	15922.724	15626.347	26041.750	10489.639	6851.130	18625.840	6905.433	32435.080
4	20217.358	38250.481	4296.140	21373.814	15782.539	12626.319	21629.823	8058.826	4804.528	16797.837	5857.365
5	8797.739	16582.793	30435.273	3957.095	17466.412	9627.174	7084.730	14874.606	5414.268	3884.931	12086.507
6	4881.523	8129.608	12537.999	20315.495	2955.815	10512.557	5642.606	4213.366	8546.703	3681.223	2704.884
7	8213.704	5548.949	5917.409	7292.970	12164.292	1458.970	6218.321	3152.245	2314.831	5323.477	1999.082
8	366.867	6809.316	5032.992	2695.297	4161.910	6832.526	809.683	2976.832	1691.443	1659.989	2891.135
9	1330.518	111.584	3962.541	4095.985	1560.201	2109.623	3948.513	415.270	1242.650	1019.842	926.209
10	653.333	1680.952	388.041	3167.021	2708.876	1869.924	3933.241	2377.347	938.869	897.482	1243.029
1+	80624.993	89483.488	92744.561	86557.923	89756.471	78320.052	67155.747	55266.007	55215.322	65925.905	71068.509

	1989	1990	1991
1	2499.917	1095.600	4344.737
2	12238.911	10232.209	4656.059
3	14017.957	20440.886	13539.512
4	26612.763	11977.417	13901.785
5	3862.685	17356.314	7500.674
6	5638.239	2581.989	7938.959
7	1270.161	2527.550	1173.225
8	788.198	710.979	897.398
9	1156.553	385.545	317.491
10	652.465	1064.453	471.508
1+	68737.849	68372.943	54741.349

The above SSBs by age (a) and year (y) are calculated following the algorithm used in the NEFSC projection program, i.e.

$$SSB(a,y) = W(a,y) \times P(a,y) \times N(a,y) \times \exp[-Z(a,y)]$$

where $Z(a,y) = 0.1667 \times M(a,y) + 0.1667 \times F(a,y)$
$N(a,y)$ - Jan 1 stock size estimates (males & females)
$P(a,y)$ - proportion mature (generally females)
$W(a,y)$ - weight at age at the beginning of the spawning season

The W(a,y) are assumed to be the same as the Jan1 weight at age estimates (see "WT AT AGE" table in input section).
Jan1 weights at age are calculated as geometric means in ADAPT from the mid-year weight at age estimates (from the catch) of the cohort in successive years.

MEAN STOCK NUMBERS (millions) - GBCOD92M

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	25113.960	21289.327	18166.183	37488.274	15664.880	8638.827	24665.698	7638.006	38345.500	14403.158	19870.429
2	3674.180	19580.835	15510.036	13218.649	25987.377	10462.991	6371.944	16843.196	5528.193	27540.383	10998.850
3	19118.599	2380.211	12145.893	8950.492	7502.704	13311.532	5017.626	3349.007	8822.657	3254.357	15283.352
4	6012.697	10029.522	1332.989	6394.562	4170.683	3314.579	6048.527	2080.490	1405.559	4334.771	1565.552
5	2179.586	3384.403	5105.640	772.627	3182.769	1799.166	1347.610	2639.502	932.467	699.758	1897.777
6	953.948	1218.351	1709.348	2527.551	384.619	1433.903	790.462	558.438	1121.953	443.008	329.013
7	1123.734	688.754	570.689	769.308	1169.076	159.201	624.102	334.225	258.978	534.850	175.452
8	32.462	650.379	488.449	237.653	354.854	576.847	70.377	226.484	153.357	144.368	222.885
9	111.784	9.203	344.397	296.378	108.561	155.250	287.971	29.444	87.029	77.412	66.007
10	41.600	109.459	20.422	140.084	125.323	99.667	201.422	134.172	53.128	48.412	61.166
1+	58362.548	59340.444	55394.048	70795.579	58650.846	39951.962	45425.738	33832.964	56708.820	51480.476	50470.483

	1989	1990	1991
1	17482.789	7513.836	16569.177
2	15229.410	11746.344	5374.199
3	6832.745	8923.169	5947.420
4	7190.256	3444.461	3520.411
5	725.038	3054.506	1244.862
6	703.826	339.924	1034.395
7	134.535	235.670	119.792
8	62.265	59.586	66.551
9	84.276	25.623	21.867
10	29.990	56.550	21.453
1+	48475.129	35399.669	33920.127

Time stamp at end of run 1992 12 9 12 20 33