Northeast Fisheries Science Center Reference Document 93-04

Assessment of the Gulf of Maine Cod Stock for 1992

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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 02543-1096, (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
by James R. Weinberg

CRD 93-03 Historic and recent trends in the population dynamics of redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine - Georges Bank region
by Ralph K. Mayo

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 Gulf of Maine region have been commercially exploited since the 17th century. Reliable landings statistics are available since 1893. Historically, the Gulf of Maine fishery can be separated into four periods (Figure 1): (1) an early era from 1893 to 1915 in which record-high landings (> 17,000 t) in 1895 and 1906 were followed by about 10 years of sharply-reduced catches; (2) a later period from 1916 to 1940 in which annual landings were relatively stable, fluctuating between 5,000 and 11,500 t, and averaging 8,300 t per year; (3) a period from 1941 to 1963 when landings sharply increased (1945: 14,500 t) and then rapidly decreased, reaching a record-low of 2,600 t in 1957; and (4) the most recent period, from 1964 onward, during which Gulf of Maine landings have generally increased. Total landings doubled between 1964 and 1968, doubled again between 1968 and 1977, and averaged 12,200 t per year during 1976-1985 (Table 1). Although Gulf of Maine landings declined between 1984 and 1987, landings have since increased reaching 17,800 t in 1991, the highest level since the early 1900s. Total landings in 1992, however, are estimated to have declined by about 40% to approximately 11,000 t.

This report presents an updated and revised analytical assessment of the Gulf of Maine cod stock (NAFO Division 5Y) for the period 1982 to 1991 based on analyses of commercial and research vessel survey data through 1991. An initial analytical assessment of this stock was presented at the Seventh NEFC Stock Assessment Workshop in November 1988 (NEFC 1989), and a subsequent revision was presented at the Twelfth Northeast Regional Stock Assessment Workshop in June 1991 (NEFSC 1991). Recreational cod catches have not been included in any of the analyses due to limited data on recreational cod landings by stock (Serchuk and Wigley 1990). However, recreational cod catches in the Gulf of Maine region are likely to range between 1,000 and 2,000 t per year.

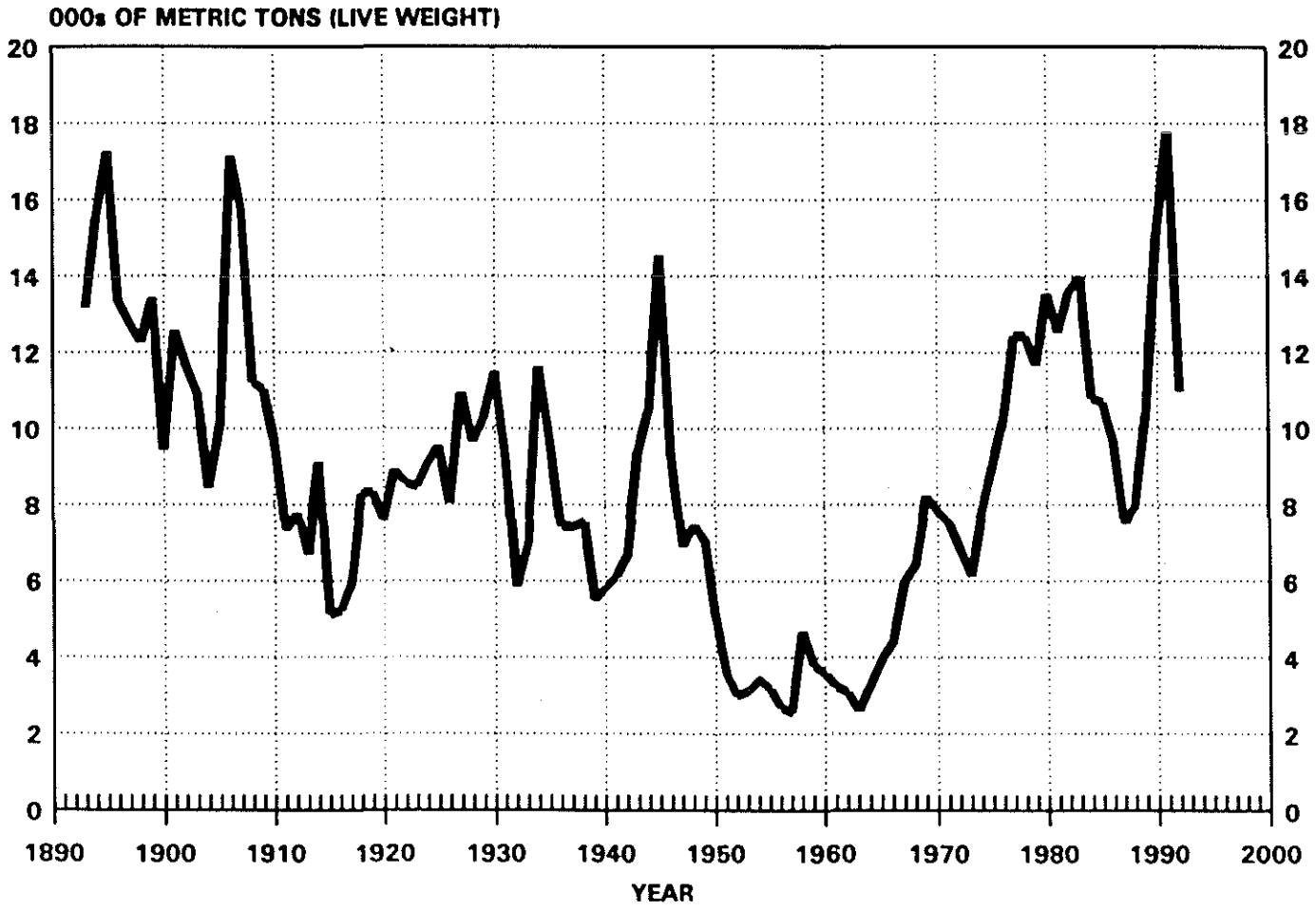

Figure 1. Total commercial landings of Gulf of Maine cod, NAFO Division 5Y, 1893-1992.

COMMERCIAL FISHERY LANDINGS

Total commercial landings in 1991 were 17,781 t, 15% greater than in 1990 and 71% greater than in 1989 (Table 1), the highest catch on record. Since 1977, the U.S. fishery has accounted for all of the commercial catch. Canadian landings reported as Gulf of Maine catch during 1977-1990 are believed, by Canadian scientists, to be misreported catches from the Scotian Shelf stock (Campana and Simon 1985; Campana and Hamel 1990). Otter trawl catches accounted for most (74%, by weight) of the 1991 landings (Table 2). Gill net catches, which composed about 40% of the total landings during 1987-1989, accounted for only 23% in 1991.

Table 1. Commercial landings (mt, live) of Atlantic cod the Gulf of Maine (NAFO Division 5Y), 1960-1992[1]

	Gulf of Maine				
Year	USA	Canada	USSR	Other	Total
1960	3448	129	-	-	3577
1961	3216	18	-	-	3234
1962	2989	83	-	-	3072
1963	2595	3	133	-	2731
1964	3226	25	-	-	3251
1965	3780	148	-	-	3928
1966	4008	384	-	-	4392
1967	5676	297	-	-	5973
1968	6360	61	-	-	6421
1969	8157	59	-	268	8484
1970	7812	26	-	423	8261
1971	7380	119	-	163	7662
1972	6776	53	11	77	6917
1973	6069	68	-	9	6146
1974	7639	120	-	5	7764
1975	8903	86	-	26	9015
1976	10172	16	-	-	10188
1977	12426	-	-	-	12426
1978	12426	-	-	-	12426
1979	11680	-	-	-	11680
1980	13528	-	-	-	13528
1981	12534	-	-	-	12534
1982	13582	-	-	-	13582
1983	13981	-	-	-	13981
1984	10806	-	-	-	10806
1985	10693	-	-	-	10693
1986	9664	-	-	-	9664
1987	7527	-	-	-	7527
1988	7958	-	-	-	7958
1989	10397	-	-	-	10397
1990	15154	-	-	-	15154
1991	17781	-	-	-	17781
1992*	11000	-	-	-	11000

[1] U.S. landings from NMFS, NEFC Detailed Weighout Files and Canvass data.
* Provisional

SAMPLING INTENSITY

A summary of U.S. length frequency and age sampling of Gulf of Maine cod landings during 1982-1991 is presented in Table 3. United States length frequency sampling averaged one sample per 155 to 200 t landed during 1983-1987, but since 1988 has decreased (1990: 1 sample per 387 t; 1991: 1 sample per 318 t). Virtually all of the U.S. samples have been taken from otter trawl landings but sampling is stratified by market category (scrod, market, and large). Of the 56 samples collected in 1991, 19 were scrod samples (34%), 30 were market (54%), and 7 were large (13%). Compared with the 1991 market category landings distribution (by weight - scrod: 26%; market: 51%; large: 20%) (Table 4), 'scrod cod' were slightly oversampled and 'large cod' undersampled.

AGE COMPOSITION

Age composition of landings during 1982-1991 was estimated by market category from monthly length frequency and age samples, pooled by calendar quarter. Quarterly mean weights by market category were obtained by 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 derive the annual catch-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 (<5%) implying that use of the length-weight equation to derive the number of fish landed imparted little, if any, bias to the calculation of catch in numbers. Gulf of Maine cod

Table 2. Distribution of U.S. commercial landings (mt, live) of Atlantic cod from the Gulf of Maine (Area 5Y), by gear type, 1965-1991. The percentage of total U.S. commercial landings of Atlantic cod from the Gulf of Maine, by gear type, is also presented for each year. Data only reflect Gulf of Maine cod landings that could be identified by gear type.

	Landings (mt, live)						Percentage of Annual Landings					
Year	Otter Trawl	Sink Gillnet	Line Trawl	Handline	Other Gear	Total	Otter Trawl	Sink Gillnet	Line Trawl	Handline	Other Gear	Total
1965	2480	501	462	168	1	3612	68.7	13.9	12.8	4.6	-	100.0
1966	2549	830	308	150	4	3841	66.4	21.6	8.0	3.9	0.1	100.0
1967	4312	734	206	274	<1	5526	78.0	13.3	3.7	5.0	-	100.0
1968	4143	1377	213	339	4	6076	68.2	22.7	3.5	5.6	-	100.0
1969	6553	851	258	162	4	7828	83.7	10.9	3.3	2.1	-	100.0
1970	5967	951	407	178	9	7512	79.4	12.7	5.4	2.4	0.1	100.0
1971	5117	1043	927	98	8	7193	71.1	14.5	12.9	1.4	0.1	100.0
1972	4004	1492	1234	54	2	6786	59.0	22.0	18.2	0.8	-	100.0
1973	3542	1182	1305	23	9	6061	58.4	19.5	21.5	0.4	0.2	100.0
1974	5056	1412	904	36	17	7425	68.1	19.0	12.2	0.5	0.2	100.0
1975	6255	1480	920	12	8	8675	72.1	17.1	10.6	0.1	0.1	100.0
1976	6701	2511	621	4	41	9878	67.8	25.4	6.3	0.1	0.4	100.0
1977	8415	2872	534	6	166[a]	11993	70.2	23.9	4.5	-	1.4	100.0
1978	7958	3438	393	10	91[b]	11890	66.9	28.9	3.3	0.1	0.8	100.0
1979	7567	2900	334	19	167[c]	10987	68.9	26.4	3.0	0.2	1.5	100.0
1980	8420	3733	251	48	61	12513	67.3	29.8	2.0	0.4	0.5	100.0
1981	7937	4102	276	23	45	12383	64.1	33.1	2.2	0.2	0.4	100.0
1982	9758	3453	188	46	34	13479	72.4	25.6	1.4	0.3	0.3	100.0
1983	9975	3744	77	4	67	13867	71.9	27.0	0.6	-	0.5	100.0
1984	6646	3985	22	3	69	10725	62.0	37.2	0.2	-	0.6	100.0
1985	7119	3090	55	6	326[d]	10596	67.2	29.1	0.5	0.1	3.1	100.0
1986	6664	2692	56	12	180[e]	9604	69.4	28.0	0.6	0.1	1.9	100.0
1987	4356	2994	70	13	68	7501	58.1	39.9	0.9	0.2	0.9	100.0
1988	4513	3308	68	27	22	7938	56.9	41.7	0.8	0.3	0.3	100.0
1989	6152	4000	72	36	119[f]	10379	59.3	38.5	0.7	0.4	1.1	100.0
1990	10420	4343	126	20	186[g]	15095	69.0	28.8	0.8	0.1	1.2	100.0
1991	13049	4158	212	59	266[h]	17744	73.5	23.4	1.2	0.3	1.5	100.0

[a] Of 166 mt landed, 107 mt were by mid-water pair trawl and 42 mt were by drifiting gill nets.
[b] Of 91 mt landed, 56 mt were by Danish seine and 27 mt were by drifting gill nets.
[c] Of 167 mt landed, 199 mt were by drifting gill nets and 38 mt were by Danish seine.
[d] Of 326 mt landed, 268 mt were by longline and 37 mt were by Danish seine.
[e] Of 181 mt landed, 152 mt were by longline and 23 mt were by Danish seine.
[f] Of 199 mt landed, 75 mt were by longline and 27 mt were by Danish seine.
[g] Of 186 mt landed, 159 mt were by longline and 16 mt were by Danish seine.
[h] Of 266 mt landed, 245 mt were by longline and 9 mt were by Danish seine.

landings in 1991 were dominated by fish from the 1987 year class with secondary contributions from the 1986 and 1988 year classes (Table 5). Together these three cohorts accounted for 91% of the total catch, by number, and 87% by weight.

MEAN WEIGHTS AT AGE

Mean weights at-age in the catch for ages 1 to 11+ during 1982-1991 are given in Table 5 and, based on landings patterns, are considered mid-year values. Apart from 1990, only slight variations are apparent among years with no consistent trends evident. In 1990, mean weights at age for age groups 2 to 4 were the lowest in the 9-year time series while mean weights for age groups 6 and 7 were the highest. These changes, however, may be artifacts of the reduced sampling intensity of the landings in 1990 as indicated by the increase in mean weights at ages 2 and 4 in 1991. Catch at age and recalculated mean weights at age for the 8+ group which are used in the VPA are given in Table 5a. Mean weights at age for calculating stock biomass at the beginning of the year are provided in Table 6. These values were derived from the catch mean weight at age data (Table 5) using the procedures described by Rivard (1980).

Table 3. U.S. sampling of commercial Atlantic cod landings from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 1991

	Number of Samples				Number of Samples, by Market Category &Quarter														Annual Sampling Intensity			
	Length Samples		Age Samples		Scrod					Market					Large					No. of Tons Landed/Sample			
Year	No.	#Fish Measured	No.	# Fish Aged	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Scd	Mkt	Lge	Σ
1982	48	3848	48	866	6	7	6	6	**25**	4	3	7	4	**18**	0	2	1	2	**5**	134	348	792	266
1983	71	5241	67	1348	14	10	10	4	**38**	4	10	6	2	**22**	1	3	5	2	**11**	106	294	318	197
1984	55	3925	55	1224	7	5	6	7	**25**	4	3	5	6	**18**	1	6	3	2	**12**	85	319	245	193
1985	69	5426	66	1546	5	6	7	5	**23**	8	6	7	4	**25**	7	5	3	6	**21**	95	229	132	155
1986	53	3970	51	1160	5	5	6	3	**19**	5	6	8	2	**21**	1	5	4	3	**13**	124	242	170	182
1987	43	3184	42	939	4	4	3	4	**15**	5	5	3	5	**18**	4	2	3	1	**10**	83	224	225	175
1988	34	2669	33	741	4	3	4	4	**15**	1	5	3	5	**14**	1	2	2	0	**5**	147	271	391	234
1989	32	2668	32	714	3	3	3	3	**12**	4	1	5	4	**14**	2	2	1	1	**6**	209	430	311	325
1990	39	2982	38	789	3	7	3	5	**18**	4	7	4	3	**18**	0	2	1	0	**3**	300	378	966	387
1991	56	4519	56	1152	2	10	4	3	**19**	5	11	11	3	**30**	0	3	3	1	**7**	250	313	519	318

Source:1978-1985 from Serchuk and Wigley (Woods Hole Lab. Ref 86-12); 1986-1991 from NEFC files.

Table 4. Percentage (by weight) of USA commercial Atlantic cod landings from Georges Bank and South (NAFO Division 5Z and Statistical Area 6) and the Gulf of Maine (NAFO Division 5Y), by market category, 1964 - 1991

	Georges Bank and South				Gulf of Maine			
Year	Large	Market	Scrod	Total[a]	Large	Market	Scrod	Total[a]
1964	45	47	8	100	29	59	12	100
1965	56	40	3	100	39	54	7	100
1966	53	37	10	100	42	48	10	100
1967	41	42	16	100	41	41	17	100
1968	34	46	19	100	47	43	9	100
1969	27	57	16	100	35	55	9	100
1970	30	62	8	100	43	52	6	100
1971	40	51	9	100	52	42	6	100
1972	37	53	10	100	58	35	7	100
1973	24	40	36	100	52	36	11	100
1974	24	59	17	100	39	33	28	100
1975	28	62	10	100	32	42	26	100
1976	34	48	18	100	29	45	20	100
1977	26	39	34	100	33	42	22	100
1978	29	60	11	100	38	44	17	100
1979	37	55	8	100	37	49	14	100
1980	41	47	12	100	36	45	19	100
1981	36	49	12	100	29	45	22	100
1982	31	47	22	100	29	45	24	100
1983	25	53	21	100	25	45	28	100
1984	31	56	12	100	26	51	19	100
1985	27	46	25	100	25	51	20	100
1986	30	47	21	100	22	51	23	100
1987	25	37	36	100	29	52	16	100
1988	27	47	24	100	26	45	23	100
1989	23	52	22	100	17	55	23	100
1990	32	44	22	100	34	43	19	100
1991	31	48	19	100	26	51	20	100

[a] Includes landings of 'mixed' cod.

STOCK ABUNDANCE AND BIOMASS INDICES

COMMMERCIAL 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 to 50 GRT; Class 3: 51 to 150 GRT; Class 4: 151 to 500 GRT) from otter trawl trips landing cod from the Gulf of Maine (Division 5Y). Indices were derived based on all trips landing cod, and for "directed" trips in which cod composed 50% or more of the total trip catch by weight (Tables 7 and 8). "Directed trips" have generally accounted for less than 45% (and as low as 14%) of U.S. Gulf of Maine otter trawl landings of cod, but since 1988 "directed trips" have accounted for an increasing percentage of the total catch (Table 9). "Directed trips" accounted for 35% of the otter trawl catch in 1988, 49% in 1989, 67% in 1990, and 71% in 1991. This trend is apparent within and among vessel class categories.

Both total and directed U.S. LPUE indices have generally exhibited similar trends (Table 7, Figure 2). LPUE values increased during the late 1960s, declined during the early 1970s, sharply increased in 1974, and then stabilized during 1975-1983 at a relatively high level. After 1983, LPUE indices trended downward, reaching record-low levels in 1987. Subsequently, both total and directed LPUE indices have increased. In 1991, the total LPUE index was the highest since 1977 (and among the highest in the time-series) while the directed index declined from the 1990 level and remains among the lowest in the time-series. Between 1988 and 1991, the percentage of total

Table 5. Catch at age (thousands of fish; mt) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982-1991

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
Total Commercial Catch in Numbers (000's) at Age												
1982	30	1380	1633	1143	633	69	91	61	41	4	33	5118
1983	-	866	2357	1058	638	422	47	61	23	9	15	5496
1984	4	446	1240	1500	437	194	74	19	15	11	17	3957
1985	-	407	1445	991	630	128	78	32	4	11	11	3737
1986	-	84	2164	813	250	177	39	24	20	4	8	3583
1987	2	216	595	1109	277	66	51	9	8	8	3	2344
1988	-	160	1443	953	406	43	9	17	1	2	1	3035
1989	-	337	1583	1454	449	81	35	6	3	5	7	3960
1990	-	205	3425	2064	430	157	27	30	10	15	17	6380
1991	-	344	934	4161	851	143	41	30	6	1	1	6512
Total Commercial Catch in Weight (Tons) at Age												
1982	24	1595	2717	3160	3019	461	813	608	531	41	613	13582
1983	-	1009	3913	2619	2410	2518	271	643	227	102	269	13981
1984	3	516	2071	4080	1607	1145	603	186	193	152	250	10816
1985	-	513	2523	2816	2814	705	615	363	51	141	152	10693
1986	-	110	3976	2375	1153	1072	296	243	253	54	132	9664
1987	2	283	1001	3641	1340	451	455	88	116	110	40	7527
1988	-	203	2715	2311	2097	295	85	191	11	36	14	7958
1989	-	420	2811	4351	1737	325	323	67	43	87	163	10397
1990	-	219	5794	4687	1834	1200	290	354	153	214	350	15095
1991	-	388	1463	10455	3520	1045	399	369	93	32	17	17781
Total Commercial Catch Mean Weight (kg) at Age												
1982	0.801	1.156	1.664	2.764	4.770	6.739	8.944	9.931	12.922	10.618	18.456	2.654[a]
1983	-	1.164	1.660	2.475	3.778	5.962	5.808	10.522	10.089	10.898	17.813	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	8.119	9.595	12.889	13.951	15.028	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	7.901	11.218	11.420	13.386	14.523	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	7.669	10.030	12.463	12.907	16.554	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	8.878	10.023	13.752	14.738	14.596	3.212
1988	-	1.268	1.881	2.426	5.166	6.767	9.932	11.126	14.960	15.763	20.356	2.622
1989	-	1.247	1.776	2.993	3.864	4.872	9.267	11.938	14.806	18.196	21.521	2.626
1990	-	1.071	1.692	2.271	4.265	7.645	10.734	11.758	15.015	14.784	20.295	2.366
1991	-	1.130	1.568	2.512	4.136	7.309	9.642	12.322	15.547	24.328	21.885	2.731
Total Commercial Catch Mean Length (cm) at Age												
1982	43.2	48.3	53.8	63.4	76.8	86.1	94.6	97.9	107.4	101.0	120.7	59.9[b]
1983	-	48.6	53.8	61.4	70.8	82.4	80.5	98.8	97.5	100.0	118.7	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	91.5	96.7	106.9	109.6	112.0	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	90.8	101.9	103.1	108.2	109.7	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	89.9	98.7	105.8	107.5	116.2	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	93.8	98.7	109.5	111.7	111.3	65.4
1988	-	50.1	56.4	61.1	78.7	86.4	98.6	102.3	113.0	114.8	125.0	61.4
1989	-	49.8	55.5	65.7	71.5	76.7	95.8	103.4	112.6	120.4	126.8	61.7
1990	-	47.5	54.8	60.0	73.7	90.0	100.9	104.0	111.8	112.6	124.6	59.2
1991	-	47.7	52.6	61.8	72.6	88.6	97.2	105.0	113.3	132.5	128.0	62.2

[a] **Mean weight**
[b] **Mean length**

trips qualifying as directed trips quadrupled (Table 9: 8% to 33%). While the total number of cod trips remained low in 1991 relative to 1988, the number of directed trips increased sevenfold over the past 3 years (Table 8: 300 trips in 1988 *vs* 2147 trips in 1991). This suggests that the very high total LPUE index for 1990 and 1991 is rather inflated due to a marked change in fleet "directivity", particularly by Class 4 vessels. In 1988, 5% of Class 4 cod trips were "directed" while in 1991, 57% of Class 4 trips qualified as "directed" (Table 9).

In terms of calculated effort (total landings/ total U.S. LPUE index), total fishing effort peaked at a record-high level in 1987 but has since declined (Table 10). To the extent that the 1990 and 1991 total LPUE indices are 'inflated' (due to increased fleet directivity for cod), the calculated

Table 5a. Catch at age (thousands of fish; mt) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Gulf of Maine stock (NAFO Division 5Y), 1982 - 1991

Year	Age 1	2	3	4	5	6	7	8+	Total
Total Commercial Catch in Numbers (000's) at Age									
1982	30	1380	1633	1143	633	69	91	139	5118
1983	-	866	2357	1058	638	422	47	108	5496
1984	4	446	1240	1500	437	194	74	62	3957
1985	-	407	1445	991	630	128	78	58	3737
1986	-	84	2164	813	250	177	39	56	3583
1987	2	216	595	1109	277	66	51	28	2344
1988	-	160	1443	953	406	43	9	21	3035
1989	-	337	1583	1454	449	81	35	21	3960
1990	-	205	3425	2064	430	157	27	72	6380
1991	-	344	934	4161	851	143	41	38	6512
Total Commercial Catch in Weight (Tons) at Age									
1982	24	1595	2717	3160	3019	461	813	1793	13582
1983	-	1009	3913	2619	2410	2518	271	1241	13981
1984	3	516	2071	4080	1607	1145	603	781	10816
1985	-	513	2523	2816	2814	705	615	707	10693
1986	-	110	3976	2375	1153	1072	296	682	9664
1987	2	283	1001	3641	1340	451	455	354	7527
1988	-	203	2715	2311	2097	295	85	252	7958
1989	-	420	2811	4351	1737	325	323	360	10397
1990	-	219	5794	4687	1834	1200	290	1071	15095
1991	-	388	1463	10455	3520	1045	399	511	17781
Total Commercial Catch Mean Weight (kg) at Age									
1982	0.801	1.156	1.664	2.764	4.770	6.739	8.944	12.892	2.654[a]
1983	-	1.164	1.660	2.475	3.778	5.962	5.808	11.473	2.544
1984	0.589	1.159	1.670	2.721	3.677	5.898	8.119	12.631	2.731
1985	-	1.260	1.746	2.840	4.466	5.525	7.901	12.169	2.861
1986	-	1.304	1.837	2.923	4.619	6.067	7.669	12.124	2.698
1987	1.028	1.313	1.684	3.283	4.831	6.824	8.878	12.724	3.212
1988	-	1.268	1.881	2.426	5.166	6.767	9.932	11.791	2.622
1989	-	1.247	1.776	2.993	3.864	4.872	9.267	17.088	2.626
1990	-	1.071	1.692	2.271	4.265	7.645	10.734	14.877	2.366
1991	-	1.130	1.568	2.512	4.136	7.309	9.642	13.399	2.731
Total Commercial Catch Mean Length (cm) at Age									
1982	43.2	48.3	53.8	63.4	76.8	86.1	94.6	106.2	59.9[b]
1983	-	48.6	53.8	61.4	70.8	82.4	80.5	101.5	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	91.5	105.8	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	90.8	104.6	62.8
1986	-	50.3	55.9	65.0	75.4	82.6	89.9	104.3	61.6
1987	47.0	50.4	54.4	67.8	76.9	86.5	93.8	106.8	65.4
1988	-	50.1	56.4	61.1	78.7	86.4	98.6	105.0	61.4
1989	-	49.8	55.5	65.7	71.5	76.7	95.8	116.6	61.7
1990	-	47.5	54.8	60.0	73.7	90.0	100.9	111.8	59.2
1991	-	47.7	52.6	61.8	72.6	88.6	97.2	107.6	62.2

[a] Mean weight
[b] Mean length

Table 6. Mean weight at age (kg) at the beginning of the year (January 1) for Atlantic cod from the Gulf of Maine cod stock (NAFO Division 5Y), 1982 - 1991. Values derived from catch mean weight-at-data (mid-year) using procedures described by Rivard (1980)

Year	Age 1	2	3	4	5	6	7	8	9	10+[a]
1982	0.791	0.965	1.364	2.364	(3.750)[b]	(5.600)	(7.400)	9.853	(11.650)	16.000
1983	0.793	1.024	1.385	2.029	3.231	5.333	6.256	9.701	10.010	16.000
1984	0.761	1.021	1.394	2.125	3.017	4.720	6.957	(9.670)	11.646	16.000
1985	0.748	1.065	1.423	2.178	3.486	4.507	6.826	9.544	10.468	16.000
1986	0.745	1.083	1.521	2.259	3.622	5.205	6.509	8.902	11.824	16.000
1987	0.758	1.087	1.482	2.456	3.758	5.614	7.339	8.767	11.744	16.000
1988	0.765	1.068	1.572	2.021	4.118	5.718	8.233	9.939	12.245	16.000
1989	0.825	1.059	1.501	2.373	3.062	5.017	7.919	10.889	12.835	16.000
1990	0.803	0.982	1.453	2.008	3.573	5.435	7.232	10.438	13.388	16.000
1991	0.803	1.008	1.296	2.062	3.065	5.583	8.586	11.501	13.520	16.000
Mean Values										
89-91	0.814	1.016	1.417	2.148	3.233	5.345	7.912	10.943	13.248	16.000
82-91	0.779	1.036	1.439	2.188	3.468	5.273	7.326	9.921	11.753	16.000

[a] **Mean weight-at-age values for 10+ set equal to mean (1982-1990) catch (mid-year) weight at age value for 10+.**
[b] **Values in parentheses are modified from calculated values.**

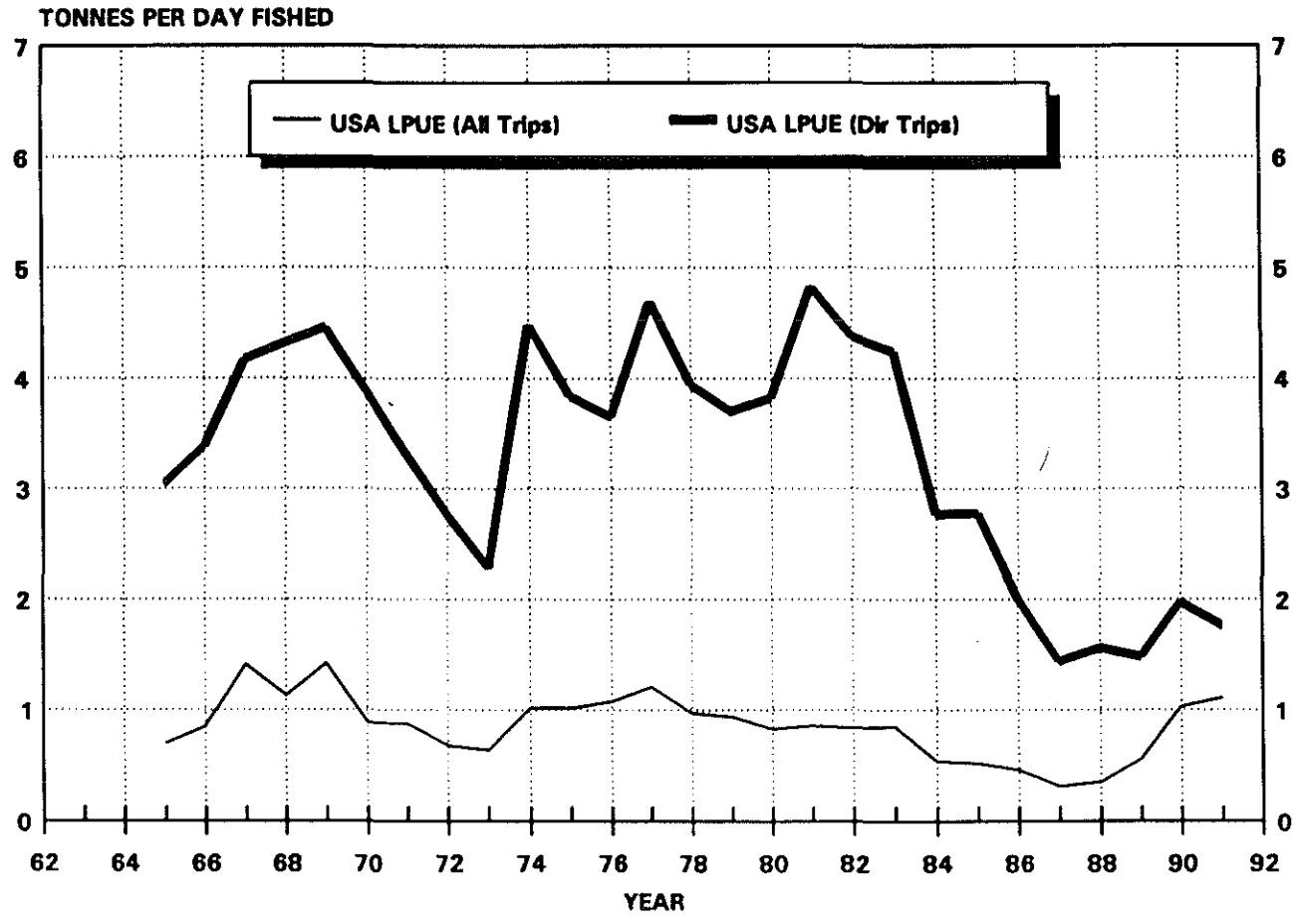

Figure 2. Trends in U.S. commercial LPUE (landings per day fished) of Gulf of Maine cod, 1965-1991. Data are based on all otter trawl trips in which cod were caught (All Trips) and on otter trawl trips in which cod composed 50% or more of the trip catch by weight (Directed Trips).

Table 7. U.S. commercial landings (L)[1], days fished (DF), and landings per day fished (L/DF)[2], by vessel tonnage class (Class 2 = 5 to 50 GRT; Class 3 = 51 to 150 GRT; Class 4 = 151to 500 GRT), of Atlantic cod for otter trawl trips catching cod from the Gulf of Maine (NAFO Division 5Y), 1965-1991. Data are also provided for otter trawl trips in which cod composed 50% or more of the total trip catch by weight ('directed trips').

Year	Class 2			Class 3			Class 4			Totals	
	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF	L	L/DF[3]
						ALL TRIPS					
1965	1412	2691	0.52	935	965	0.97	46	92	0.50	2393	0.70
1966	1265	2379	0.53	1093	938	1.17	113	83	1.36	2471	0.85
1967	1790	2175	0.82	2341	1232	1.90	108	196	0.55	4239	1.41
1968	1839	2696	0.68	1955	1266	1.54	219	182	1.20	4013	1.13
1969	2992	3301	0.91	2874	1497	1.92	549	337	1.63	6415	1.42
1970	3359	4834	0.69	2010	1666	1.21	389	425	0.92	5758	0.89
1971	2917	4000	0.73	1727	1475	1.17	293	422	0.69	4937	0.88
1972	2190	4104	0.53	1463	1637	0.89	192	244	0.79	3845	0.68
1973	2018	3915	0.52	1172	1430	0.82	194	252	0.77	3384	0.64
1974	2292	3954	0.58	2108	1455	1.45	458	367	1.25	4858	1.02
1975	3108	4423	0.70	2599	1818	1.43	311	373	0.83	6018	1.02
1976	3168	4404	0.72	3143	2096	1.50	262	527	0.50	6573	1.08
1977	3816	4354	0.88	3903	2448	1.59	341	631	0.54	8060	1.21
1978	3859	5063	0.76	3334	2618	1.27	489	809	0.60	7682	0.97
1979	3731	5623	0.66	3169	2425	1.31	475	779	0.61	7375	0.94
1980	3967	6252	0.63	3497	3181	1.10	571	908	0.63	8035	0.83
1981	3722	4912	0.76	3253	3277	0.99	737	986	0.75	7712	0.86
1982	3619	6086	0.59	4466	4343	1.03	1281	1448	0.88	9366	0.84
1983	3473	5512	0.63	4874	4731	1.03	1326	1782	0.74	9673	0.85
1984	2188	5444	0.40	3217	5042	0.64	883	1668	0.53	6288	0.54
1985	1801	4890	0.37	3457	5921	0.58	1515	2675	0.57	6773	0.52
1986	1638	4721	0.35	3088	6149	0.50	1513	2990	0.51	6239	0.46
1987	1131	4782	0.24	2005	6417	0.31	1012	2724	0.37	4148	0.31
1988	1327	5089	0.26	2137	5446	0.39	830	2105	0.39	4294	0.35
1989	1559	4060	0.38	2885	4969	0.58	1334	1882	0.71	5778	0.56
1990	2004	4282	0.47	4749	5351	0.89	3212	2029	1.58	9965	1.03
1991	2466	4460	0.55	5272	6042	0.87	4318	2532	1.71	12056	1.11
						50% TRIPS					
1965	394	183	2.15	310	74	4.19	1	1	1.00	705	3.05
1966	253	92	2.75	329	85	3.87	12	4	3.00	594	3.38
1967	656	179	3.66	1202	270	4.45	1	1	1.00	1859	4.17
1968	656	155	4.23	995	224	4.44	50	16	3.13	1701	4.32
1969	1399	324	4.32	1384	292	4.74	104	38	2.74	2887	4.46
1970	1369	395	3.47	719	152	4.73	46	15	3.07	2134	3.89
1971	1033	370	2.79	540	124	4.35	74	24	3.08	1647	3.31
1972	621	283	2.19	322	88	3.66	46	11	4.18	989	2.76
1973	380	179	2.12	96	33	2.91	1	1	1.00	477	2.28
1974	467	186	2.51	529	92	5.75	181	31	5.84	1177	4.48
1975	1047	331	3.16	1039	232	4.48	66	14	4.71	2152	3.84
1976	1197	384	3.12	1277	308	4.15	22	6	3.67	2496	3.65
1977	1390	386	3.60	1825	334	5.46	44	6	7.33	3259	4.69
1978	1314	421	3.12	1373	297	4.62	48	7	6.86	2735	3.94
1979	1114	382	2.92	1233	287	4.30	46	7	6.57	2393	3.70
1980	1198	360	3.33	1205	283	4.26	99	22	4.50	2502	3.82
1981	1587	317	5.01	1218	273	4.46	98	15	6.53	2903	4.83
1982	1354	381	3.55	2296	499	4.60	334	54	6.19	3984	4.38
1983	1399	397	3.52	2609	603	4.33	224	29	7.72	4232	4.24
1984	478	215	2.22	941	313	3.01	21	5	4.20	1440	2.77
1985	438	269	1.63	1024	319	3.21	205	67	3.06	1667	2.78
1986	398	249	1.60	602	295	2.04	143	49	2.92	1143	2.00
1987	253	180	1.41	273	206	1.33	79	41	1.93	605	1.44
1988	426	366	1.16	936	551	1.70	136	74	1.84	1498	1.56
1989	829	601	1.38	1579	1049	1.51	435	281	1.55	2843	1.48
1990	1265	920	1.38	3404	1800	1.89	2015	814	2.48	6684	1.97
1991	1693	1307	1.30	3749	2391	1.57	3150	1410	2.23	8592	1.76

[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 L/DF was derived by weighting individual tonnage class L/DF values by the percentage of total landings accounted for by each vessel class and summing over the three vessel class categories.**

Table 8. U.S. commercial vessel trips (T), days fished (DF)[1], and average days fished per trip (DF/T), by vessel tonnage class (Class 2: 5 to 50 GRT; Class 3: 51 to 150 GRT; Class 4: 151 to 500 GRT), of Atlantic cod for otter trawl trips catching cod from the Gulf of Maine (NAFO Division 5Y), 1965 to 1991. Data are also provided for otter trawl trips in which cod composed 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	5354	2691	0.50	1145	965	0.84	60	92	1.53	6559	3748	0.57
1966	4637	2379	0.51	1130	938	0.83	38	83	2.18	5805	3400	0.59
1967	3903	2175	0.56	1277	1232	0.96	98	196	2.00	5278	3603	0.68
1968	3587	2696	0.75	1293	1266	0.98	99	182	1.84	4979	4144	0.83
1969	3679	3301	0.90	1494	1497	1.00	186	337	1.81	5359	5135	0.96
1970	4342	4834	1.11	1585	1666	1.05	214	425	1.99	6141	6925	1.13
1971	3908	4000	1.02	1272	1475	1.16	204	422	2.07	5384	5897	1.10
1972	3933	4104	1.04	1326	1637	1.23	130	244	1.88	5389	5985	1.11
1973	4688	3915	0.84	1241	1430	1.15	146	252	1.73	6075	5597	0.92
1974	5145	3954	0.77	1274	1455	1.14	193	367	1.90	6612	5776	0.87
1975	5498	4423	0.80	1437	1818	1.27	198	373	1.88	7133	6614	0.93
1976	4734	4404	0.93	1687	2096	1.24	228	527	2.31	6649	7027	1.06
1977	4664	4354	0.93	2010	2448	1.22	298	631	2.12	6972	7433	1.07
1978	4655	5063	1.09	1754	2618	1.49	444	809	1.82	6853	8490	1.24
1979	5218	5623	1.08	1777	2425	1.36	445	779	1.75	7440	8827	1.19
1980	5344	6252	1.17	2240	3181	1.42	396	908	2.29	7980	10341	1.30
1981	7131	4912	0.69	2879	3277	1.14	385	986	2.56	10395	9175	0.88
1982	7737	6086	0.79	3148	4343	1.38	448	1448	3.23	11333	11877	1.05
1983	7460	5512	0.74	3575	4731	1.32	446	1782	4.00	11481	12025	1.05
1984	7006	5444	0.78	3554	5042	1.42	403	1668	4.14	10963	12154	1.11
1985	6196	4890	0.79	3612	5921	1.64	649	2675	4.12	10457	13486	1.29
1986	4868	4721	0.97	3582	6149	1.72	700	2990	4.27	9150	13860	1.51
1987	4058	4782	1.18	3023	6417	2.12	604	2724	4.51	7685	13923	1.81
1988	4154	5089	1.23	2965	5446	1.84	489	2105	4.30	7608	12640	1.66
1989	3379	4060	1.20	2405	4969	2.07	412	1882	4.57	6196	10911	1.76
1990	3052	4282	1.40	2202	5351	2.43	515	2029	3.94	5769	11662	2.02
1991	3796	4460	1.17	2162	6042	2.79	540	2532	4.69	6498	13034	2.01
						50% TRIPS						
1965	493	394	0.80	116	74	0.64	2	1	0.50	611	469	0.77
1966	241	253	1.05	102	84	0.82	2	4	2.00	345	341	0.99
1967	418	656	1.57	231	270	1.17	1	1	1.00	650	927	1.43
1968	386	656	1.70	251	224	0.89	7	16	2.29	644	896	1.39
1969	645	1399	2.17	325	292	0.90	15	38	2.53	985	1729	1.76
1970	695	1369	1.97	217	152	0.70	11	15	1.36	923	1536	1.66
1971	550	1033	1.88	193	124	0.64	7	24	3.43	750	1181	1.57
1972	492	621	1.26	134	88	0.66	9	11	1.22	635	720	1.13
1973	354	380	1.07	54	33	0.61	2	1	0.50	410	414	1.01
1974	491	467	0.95	98	92	0.94	17	31	1.82	606	590	0.97
1975	676	1047	1.55	218	232	1.06	11	14	1.27	905	1293	1.43
1976	554	1197	2.16	334	308	0.92	6	6	1.00	894	1511	1.69
1977	492	1390	2.83	391	334	0.85	10	6	0.60	893	1730	1.94
1978	460	1314	2.86	281	297	1.06	6	7	1.17	747	1618	2.17
1979	504	1114	2.21	331	287	0.87	10	7	0.70	845	1408	1.67
1980	500	1198	2.40	360	283	0.79	12	22	1.83	872	1503	1.72
1981	752	1587	2.11	390	273	0.70	13	15	1.15	1155	1875	1.62
1982	802	1354	1.69	565	499	0.88	23	54	2.35	1390	1907	1.37
1983	910	1399	1.54	855	603	0.71	24	29	1.21	1789	2031	1.14
1984	427	215	0.50	334	313	0.94	1	5	5.00	762	533	0.70
1985	397	269	0.68	331	319	0.96	18	67	3.72	746	655	0.88
1986	240	249	1.04	232	294	1.27	16	49	3.06	488	592	1.21
1987	164	180	1.10	121	206	1.70	15	41	2.73	300	427	1.42
1988	267	366	1.37	342	551	1.61	23	74	3.22	632	991	1.57
1989	456	601	1.32	515	1049	2.04	65	281	4.32	1036	1931	1.86
1990	537	920	1.71	780	1800	2.31	226	814	3.60	1543	3534	2.29
1991	1037	1307	1.26	803	2391	2.98	307	1410	4.59	2147	5108	2.38

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

Table 9. Percentage, within vessel tonnage class[1], of Atlantic cod otter trawl landings (L)[2], vessel trips (T), and effort (DF)[3] from the Gulf of Maine (NAFO Division 5Y) accounted for by otter-trawl trips in which cod composed 50% or more of the total trip catch by weight ('directed trips'), 1965-1991.

	Class 2			Class 3			Class4			Totals		
Year	L	T	DF	L	T	DF	L	T	DF	L	T	DF
1965	27.9	9.2	14.6	33.2	10.1	7.7	2.2	3.3	1.1	29.5	9.3	12.5
1966	20.0	5.2	<0.1	30.1	9.0	9.0	10.6	5.3	4.8	24.0	5.9	10.0
1967	36.6	10.7	30.2	51.3	18.1	21.9	0.9	1.0	0.5	43.9	12.3	25.7
1968	35.7	10.8	24.3	50.9	19.4	17.7	22.8	7.1	8.8	42.4	12.9	21.6
1969	46.8	17.5	42.4	48.2	21.8	19.5	18.9	8.1	11.3	45.0	18.4	33.7
1970	40.8	16.0	28.3	35.8	13.7	9.1	11.8	5.1	3.5	37.1	15.0	22.2
1971	35.4	14.1	25.8	31.3	15.2	8.4	25.3	3.4	5.7	33.4	13.9	20.0
1972	28.4	12.5	15.1	22.0	10.1	5.4	24.0	6.9	4.5	25.7	11.8	12.0
1973	18.8	7.6	9.7	8.2	4.4	2.3	0.5	1.4	0.4	14.1	6.7	7.4
1974	20.4	9.5	11.8	25.1	7.7	6.3	39.5	8.8	8.4	24.2	9.2	10.2
1975	33.7	12.3	23.7	40.0	15.2	12.8	21.2	5.6	3.8	35.8	12.7	19.5
1976	37.8	11.7	27.2	40.6	19.8	14.7	8.4	2.6	1.1	38.0	13.4	21.5
1977	36.4	10.5	31.9	46.8	19.5	13.6	12.9	3.4	1.0	40.4	12.8	23.3
1978	34.1	9.9	26.0	41.2	16.0	11.3	9.8	1.4	0.9	35.6	10.9	19.1
1979	29.9	9.7	19.8	38.9	18.6	11.8	9.7	2.2	0.9	32.4	11.4	16.0
1980	30.2	9.4	19.2	34.5	16.1	8.9	17.3	3.0	2.4	31.1	10.9	14.5
1981	42.6	10.5	32.3	37.4	13.5	8.3	13.3	3.4	1.5	37.6	11.1	20.4
1982	37.4	10.4	22.2	51.4	17.9	11.5	26.1	5.1	3.7	42.5	12.3	16.1
1983	40.3	12.2	25.4	53.5	23.9	12.7	16.9	5.4	1.6	43.8	15.6	16.9
1984	21.8	6.1	3.9	29.3	9.4	6.2	2.4	0.2	0.3	22.9	7.0	4.4
1985	24.3	6.4	5.5	29.6	9.2	5.4	13.5	2.8	2.5	24.6	7.1	4.9
1986	24.3	4.9	5.3	19.5	6.5	4.8	9.5	2.3	1.6	18.3	5.3	4.3
1987	22.4	4.0	3.8	13.6	4.0	3.2	7.8	2.5	1.5	14.6	3.9	3.1
1988	32.1	6.4	7.2	43.8	11.5	10.1	16.4	4.7	3.5	34.9	8.3	7.8
1989	53.2	13.5	14.8	54.7	21.4	21.1	32.6	15.8	14.9	49.2	16.7	17.7
1990	63.1	17.6	21.5	71.7	35.4	33.6	62.7	43.9	40.1	67.1	26.7	30.3
1991	68.7	27.3	29.3	71.1	37.1	39.6	73.0	56.9	55.7	71.3	33.0	39.2

[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.**

effort values for 1990 and 1991 are underestimated.

Fishing effort was standardized by applying a four-factor (year, tonnage class, area, and depth) General Linear Model (GLM) to log LPUE data derived for all otter trawl trips taking cod from 1982 through 1991 (Table 11). The model accounted for just over 20% of the total sum of squares, although all four factors accounted for highly significant effects. Retransformed log year coefficients were multiplied by the 1982 base year LPUE and divided into the annual total landings (from Table 10) to derive the effort values given at the bottom of Table 11. Both series of effort estimates (Tables 10 and 11) show the same trends over time with peak effort occurring in 1987 followed by a decline in 1989 and 1990. The GLM standardized series shows a subsequent increase (+17%) in effort in 1991 over 1990 compared to the effort trend estimated from the calculated LPUE indices (Figure 3).

RESEARCH VESSEL SURVEY INDICES

Indices of cod abundance (stratified mean catch per tow in numbers) and biomass (stratified mean weight per tow in kilograms), developed from Northeast Fisheries Science Center (NEFSC) and State of Massachusetts research vessel bottom trawl surveys, have been used to monitor changes and assess trends in population size and recruitment of U.S. cod populations since 1963. Offshore (> 27 m) stratified random NEFSC surveys have been conducted annually in the Gulf of Maine in autumn since 1963 and in spring since 1968. Inshore areas (< 27 m) have been sampled since 1978 during spring and autumn NEFSC and Commonwealth of Massachusetts 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 has been used.

Table 10. Total and U.S. commercial landings, U.S. landings per unit of effort indices (LPUE, all cod trips), and derived effort indices for Gulf of Maine cod, 1965-1991

Year	Total Landings (mt)	U.S. Landings (mt)	U.S. LPUE Index (All cod trips)	Total Calculated Days Fished	U.S. Calculated Days Fished
1965	3928	3780	0.6954	5649	5436
1966	4392	4008	0.8510	5161	4710
1967	5973	5676	1.4096	4237	4027
1968	6421	6360	1.1273	5696	5642
1969	8484	8157	1.4241	5957	5728
1970	8261	7812	0.8871	9312	8806
1971	7662	7380	0.8815	8692	8372
1972	6917	6776	0.6800	10172	9965
1973	6146	6069	0.6382	9630	9510
1974	7764	7639	1.0207	7607	7484
1975	9015	8903	1.0220	8821	8711
1976	10188	10172	1.0842	9397	9382
1977	12426	12426	1.2094	10275	10275
1978	12426	12426	0.9712	12794	12794
1979	11680	11680	0.9361	12477	12477
1980	13528	13528	0.8346	16209	16209
1981	12534	12534	0.8561	14641	14641
1982	13582	13582	0.8395	16179	16179
1983	13981	13981	0.8466	16514	16514
1984	10806	10806	0.5410	19974	19974
1985	10693	10693	0.5219	20489	20489
1986	9664	9664	0.4630	20873	20873
1987	7527	7527	0.3056	24630	24630
1988	7958	7958	0.3498	22750	22750
1989	10397	10397	0.5561	18696	18696
1990	15154	15154	1.0279	14743	14743
1991	17781	17781	1.1054	16086	16086

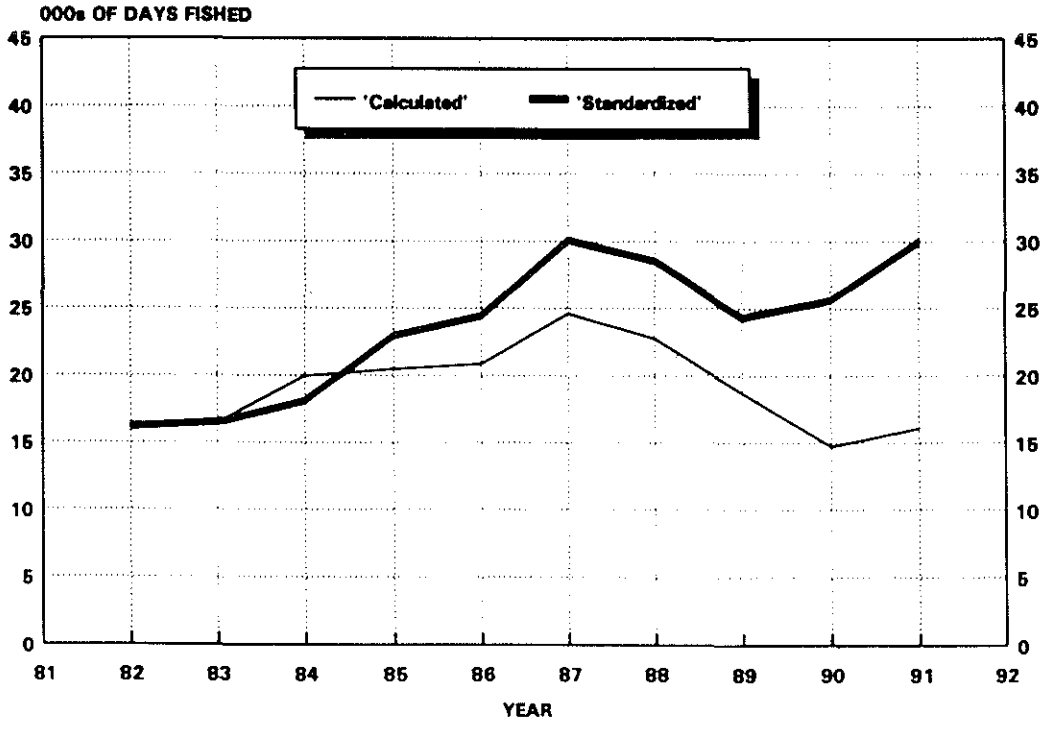

Figure 3. Trends in calculated and standardized U.S. fishing effort for Gulf of Maine cod, 1982-1991.

Table 11. Gulf of Maine cod effort (days) standardization. Standard - Year = 82, TC = 25; Area = 514; Depth = 3, using all unsummed data, no exclusions.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: LCPE

Source	DF	Sum of Squares	Mean Square	F Value	PR > F	R-Square	CV
Model	25	9908.15332392	396.32613296	246.74	0.0	0.200955	19.4383
Error	24527	39397.29203143	1.60628255		ROOT MSE		LCPE MEAN
Corrected total	24552	49305.44535535			1.26739203		6.52007997

Source	DF	TYPE I SS	F Value	PR > F	DF	Type II SS	F Value	PR > F
Year	9	3941.02391770	272.61	0.0	9	3856.03244858	266.73	0.0
TC2	8	3449.60824843	268.45	0.0	8	4828.89313684	375.78	0.0
Area	4	629.15341636	97.92	0.0	4	237.33398628	36.94	0.0001
Depth	4	1888.36774144	293.90	0.0	4	1888.36774144	293.90	0.0

Source	DF	TYPE III SS	F Value	PR > F	DF	TYPE IV SS	F Value	PR > F
Year	9	3856.03244858	266.73	0.0	9	3856.03244858	266.73	0.0
TC2	8	4828.89313684	375.78	0.0	8	4828.89313684	375.78	0.0
Area	4	237.33398628	36.94	0.0001	4	237.33398628	36.94	0.0001
Depth	4	1888.36774144	293.90	0.0	4	1888.36774144	293.90	0.0

Parameter		Estimate	T For HO: Parameter=0	PR > |T|	STD Error of Estimate	Re-Transformed Year Coefficient	Standardized Effort (Days)
Intercept		6.39120886 B	163.71	0.0	0.03903990		
Year	82	0.00000000 B				1	16178.68
	83	0.00942655 B	0.26	0.7968	0.03660082	1.010148	16486.66
	84	-0.34164384 B	-9.03	0.0001	0.03782350	0.71111	18101.22
	85	-0.58924208 B	-15.90	0.0	0.03704764	0.555129	22944.86
	86	-0.75317122 B	-21.02	0.0	0.03583169	0.471173	24431.80
	87	-1.21118871 B	-32.72	0.0	0.03701233	0.298047	30082.68
	88	-1.10178094 B	-29.84	0.0	0.03692410	0.332505	28509.18
	89	-0.67544341 B	-16.86	0.0	0.04006213	0.509339	24315.32
	90	-0.35543452 B	-9.13	0.0001	0.03891575	0.7014	25635.78
	91	-0.34816807 B	-9.01	0.0001	0.03862816	0.706507	29979.12

Table 12. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine (strata 26-30 and 36-40), 1963-1992. [a,b]

	Gulf of Maine[c]			
	Spring		Autumn	
Year	No./Tow	Wt/Tow	No./Tow	Wt/Tow
1963	-	-	5.92	17.9
1964	-	-	4.00	22.8
1965	-	-	4.49	12.0
1966	-	-	3.78	12.9
1967	-	-	2.56	9.2
1968	5.44	17.9	4.34	19.4
1969	3.25	13.2	2.76	15.4
1970	2.21	11.1	4.90	16.4
1971	1.43	7.0	4.37	16.5
1972	2.06	8.0	9.31	13.0
1973	7.54	18.8	4.46	8.7
1974	2.91	7.4	4.33	9.0
1975	2.51	6.0	6.15	8.6
1976	2.78	7.6	2.15	6.7
1977	3.88	8.5	3.08	10.2
1978	2.06	7.7	5.75	12.9
1979	4.27	9.5	3.49	17.5
1980	2.15	6.2	7.04	14.2
1981	4.86	10.8	2.42	8.1
1982	3.75	8.6	7.77	16.1
1983	3.91	10.5	4.22	8.8
1984	3.40	5.8	2.42	8.8
1985	2.52	7.7	2.92	8.5
1986	1.96	3.6	1.95	5.1
1987	1.68	3.0	2.98	3.4
1988	3.13	3.3	5.90	6.6
1989	2.26	2.5	4.65	4.6
1990	2.36	3.1	2.99	4.9
1991	2.39	2.9	1.25	2.8
1992	2.39	8.7	1.27	2.1

[a] **During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse 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 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 differences.**

[c] **In the Gulf of Maine, spring surveys during 1980-1982 and 1989-1991 and autumn surveys during 1977-1978, 1980, 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 0.79 and 0.67 (weight) were used in this standardization (NEFC 1991).**

Prior to 1985, BMV oval doors (550 kg) were used in all NEFSC surveys; since 1985, Portuguese polyvalent doors (450 kg) have been used. Details on NEFSC survey sampling design and procedures are provided in Azarovitz (1981) and Clark (1981). The State of Massachusetts inshore bottom trawl sampling program is described in Howe *et al.* (1981). No adjustments in the survey catch per tow data for cod have been made for any of the trawl differences, but vessel and door coefficients have been applied to adjust the stratified means (number and weight per tow) as described in Table 12. Unadjusted catch per tow (number) at age indices from NEFSC spring and autumn surveys are listed in Appendix 1:Table 1 and standardized catch per tow (number) at age indices are listed in Appendix 1:Table 2. Catch per tow (number) at age indices from Massachusetts spring and autumn surveys are listed in Appendix 1:Table 3.

NEFSC spring and autumn offshore catch per tow indices for Gulf of Maine cod have generally exhibited similar trends throughout the survey time series (Table 12, Figure 4). Number per tow indices declined during the mid- and late 1960s but since 1972/73 have fluctuated as a result of a series of recruitment pulses. Sharp increases in the number per tow indices reflect above average recruitment of the 1971, 1973, 1977-1980, 1983, and 1985-1987 year classes at ages 1 and 2 (Appendix 1:Table 2, Figure 5). The sequential dominance of these cohorts at older ages can be discerned from number per tow at age values in both spring and autumn NEFSC surveys (Appendix 1:Table 2).

Spring NEFSC number per tow indices have remained relatively stable since 1985 at a level below the 1981-1984 period (Table 12); spring weight per tow indices have also remained relatively low through 1991 but the index increased substantially in 1992 due to a large contribution from the 1987 year class (Appendix 1:Table 2). Autumn number and weight per tow indices declined sharply in 1990 to a record low level, and remain low through 1992. The increases in the 1988 and 1989 autumn number per tow indices, due to recruitment of the strong 1986 and 1987 year classes, were dissipated by 1990 and 1991, resulting in the sharp declines in the overall index. This reduction, combined with a general paucity of large fish in the survey indices (Appendix 1:Table 2) in recent years has resulted in the sharp decline in the weight per tow indices in 1990 and 1991 as well. Overall, the 1987 year class appears to have been one of the strongest ever produced; catch per tow indices of this cohort at ages 1 to 3 in the NEFSC autumn surveys and at ages 0 and 1 in the Massachu-

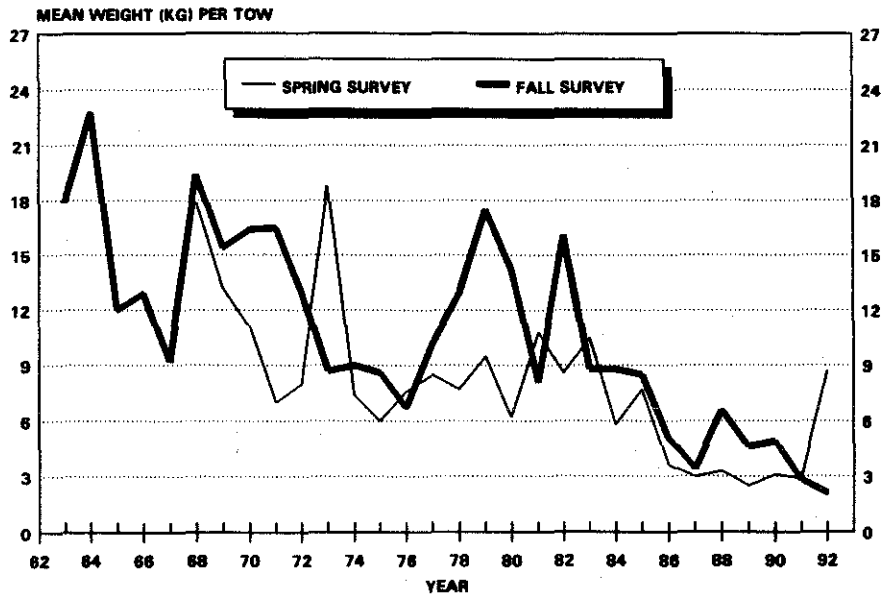

Figure 4. Standardized stratified mean catch per tow (kg) of Atlantic cod in the NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-1992.

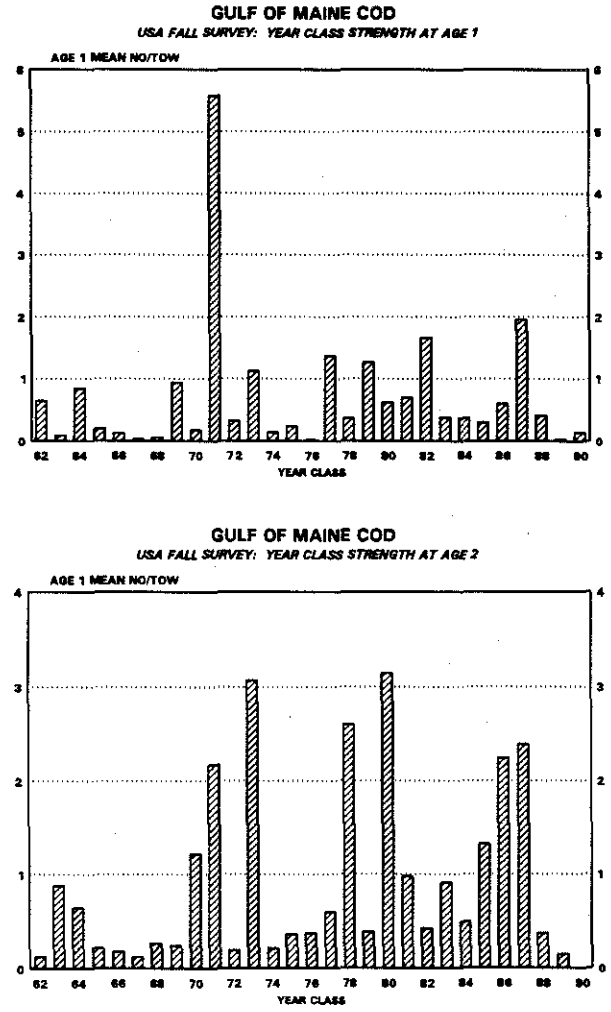

Figure 5. Relative year class strength of Gulf of Maine cod at age 1 and age 2 based on standardized catch per tow (number) indices from NEFSC autumn research vessel bottom trawl surveys, 1963-1991.

Table 13. Estimates of instantaneous total mortality (Z) and fishing mortality (F)[1] for Gulf of Maine Atlantic cod for eight time periods, 1964-1990, derived from NEFSC offshore spring and autumn bottom trawl survey data[2]

Time Period	Gulf of Maine					
	Spring		Autumn		Geometric Mean	
	Z	F	Z	F	Z	F
1964-67	-	-	0.39	0.19	0.39	0.19
1968-72	0.37[3]	0.17	0.43[6]	0.23	0.40	0.20
1973-76	0.35[4]	0.15	0.45	0.25	0.40	0.20
1977-81	0.52	0.32	0.57[7]	0.37	0.54	0.34
1982-84	0.73	0.53	0.78	0.58	0.75	0.55
1985-87	0.58[5]	0.38	1.05	0.85	0.78	0.58
1988-90	1.24	1.04	0.72	0.61	0.94	0.74

[1] Instantaneous natural mortality (M) assumed to be 0.20.
[2] Estimates derived from:
Gulf of Maine spring:
ln (Σ age 4+ for year i to j/ Σ age 5+ for years i+1 to j+1).
Gulf of Maine autumn:
ln (Σ age 3+ for years i-1 to j-1/ Σ age 4+ for years i to j).
[3] Excludes spring 1972-1973 data (4+/5+) since these gave large negative Z value.
[4] Excludes spring 1973-1974 data (4+/5+) since these gave unreasonably high Z value.
[5] Excludes spring 1985-1986 data (4+/5+) since these gave unreasonably high Z value.
[6] Excludes autumn 1967-1968 data (3+/4+) since these gave large negative Z value.
[7] Excludes autumn 1976-1977 data (3+/4+) since these gave large negative Z value.

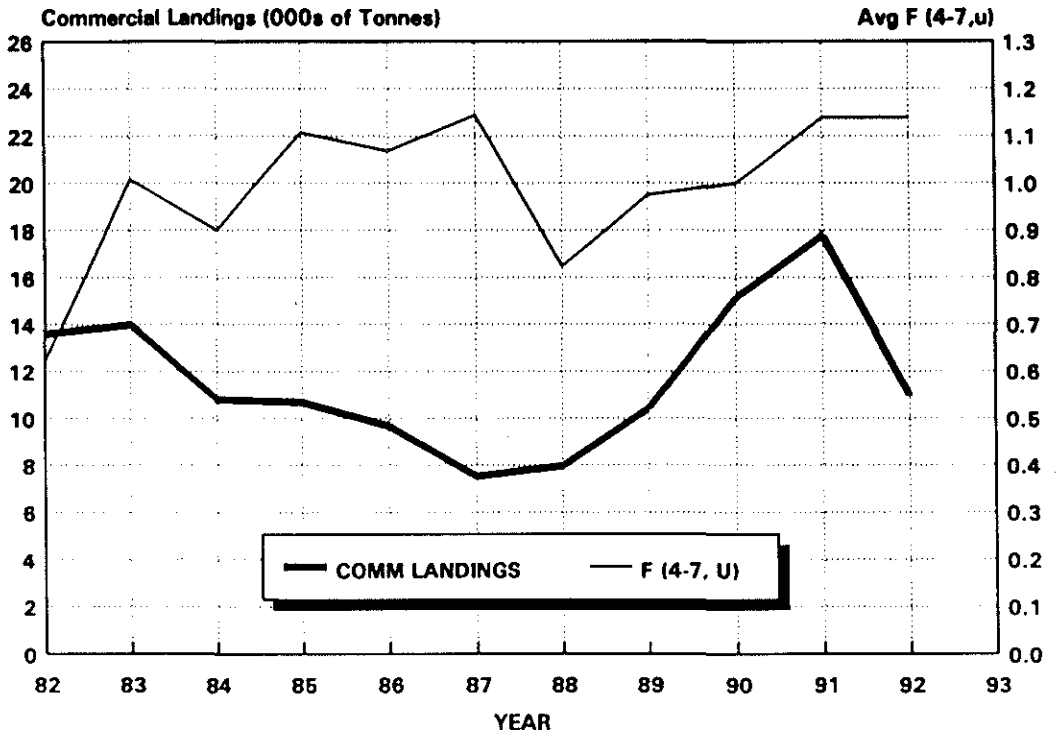

Figure 6. Trends in total commercial landings and fishing mortality for Gulf of Maine cod, 1982-1992.

setts autumn inshore surveys were nearly all record-high values (Appendix 1:Tables 2 and 3).

Based on NEFSC survey catch per tow indices in 1989-1992, the 1988-1991 year classes of Gulf of Maine cod appear to be average or below average.

MORTALITY

NATURAL MORTALITY

Instantaneous natural mortality (M) for Gulf of Maine 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 eight time periods encompassed by the NEFSC autumn and spring offshore surveys: 1964-1967, 1968-1972, 1973-1976, 1977-1981, 1982-1984, 1985-1987, and 1988-1990 (Table 13). Total mortality was calculated from survey catch per tow at age data (Appendix 1:Table 2) 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:

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 period.

The pooled estimates indicate that total mortality was relatively low (Z = 0.40) between 1964 and 1976 but significantly increased afterward to 0.75 to 0.78 during 1982-1987. Total mortality increased further to 0.94 during the 1988-1990. Except for the 1988-1990 period, values of Z derived from the spring surveys are slightly 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 trial formulations were evaluated. Bottom trawl survey indices for ages 2 to 6 were used for the spring and autumn NEFSC surveys, while ages 3 to 6 were used for the U.S. commercial LPUE data. The second calibration included additional indices for ages 2 to 4 from Massachusetts spring and ages 2 and 3 from Massachusetts autumn surveys. Virtual population analyses were performed in each case employing an 8+ group.

The inclusion of Massachusetts indices resulted in an increase in the coefficients of variation (CV) of the estimated stock sizes and Qs, although most of the variability was attributed to the age 3 autumn index. Thus, the final calibration was performed using all of the indices described earlier, with the exception of the Massachusetts autumn age 3 index. All indices were given equal weight. Stock sizes corresponding to the 1986-1990 year classes were estimated for ages 2 to 6 in 1992 to generate fishing mortalities at ages 2 to 5 in 1991. A flat-topped partial recruitment pattern was employed with full F on ages 4 and older as indicated from a separable VPA. Thus, F for ages 6 and older in the terminal year was set equal to the unweighted mean F of ages 4 and 5. In years prior to the terminal year, F on the oldest true age was determined from estimates of Z for ages 4 to 7. F for the plus group was set equal to F on the oldest true age.

Full results from the final VPA calibration are presented in Appendix 2 and estimates of F, stock size, and spawning stock biomass are given in Table 14. The final calibration yielded very low correlations (< 0.10) among estimates of slopes (Q) and moderately low correlations (< 0.20) between stock sizes and Qs. All parameter estimates were significant in both analyses.

Average (ages 4-7, unweighted) fishing mortality in 1991 was estimated at 1.14 (Table 14, Figure 6), a 14% increase over 1990. The 14% increase in mean fully recruited F is consistent with the 17% increase in standardized fishing effort indicated by the General Linear Model (Table 11). Spawning stock biomass declined from a 1990 maximum of 27,500 t to 21,200 t in 1991. The 1987 year class (16.3 million) is the highest in the 1982-1990 series and almost twice the size of the above-average 1980 and 1986 year

Table 14. Stock size, fishing mortality, and spawning stock biomass obtained from VPA calibrated with NEFSC and Massachusetts spring and autumn survey indices and U.S. commercial CPUE at age indices for Gulf of Maine cod

Stock Numbers (Jan 1) in millions - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	6080.809	5632.941	7753.562	4810.749	7288.093	9809.079	19943.296	3966.289	2670.369	4537.261	0.000
2	9122.486	4978.544	4611.861	6348.078	3938.707	5966.985	8030.993	16328.189	3247.322	2186.312	3714.794
3	4358.791	6220.184	3292.498	3372.315	4829.098	3148.735	4689.909	6430.447	13063.460	2473.191	1478.737
4	2672.279	2091.076	2959.954	1573.671	1453.528	1995.663	2039.588	2534.092	3832.447	7596.389	1179.759
5	1477.367	1153.648	754.711	1066.149	391.719	454.415	630.446	807.563	759.106	1270.158	2454.368
6	179.711	636.804	367.241	222.491	302.842	94.503	121.404	148.802	254.905	232.423	269.901
7	210.952	84.701	139.529	125.133	66.341	87.789	17.653	60.489	48.537	66.639	60.900
8	318.271	191.317	115.035	91.152	93.490	47.319	40.567	35.636	127.218	60.531	33.321
1+	**24420.665**	**20989.216**	**19994.390**	**17609.739**	**18363.818**	**21604.488**	**35513.857**	**30311.507**	**24003.363**	**18422.903**	**9191.781**

Fishing Mortality - GMCOD92

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.1829	0.2135	0.1130	0.0735	0.0239	0.0408	0.0223	0.0231	0.0723	0.1910
3	0.5345	0.5426	0.5382	0.6416	0.6837	0.2343	0.4156	0.3175	0.3421	0.5402
4	0.6400	0.8191	0.8211	1.1906	0.9627	0.9523	0.7265	1.0054	0.9044	0.9298
5	0.6416	0.9447	1.0214	1.0586	1.2219	1.1199	1.2438	0.9531	0.9836	1.3488
6	0.5522	1.3182	0.8766	1.0101	1.0383	1.4777	0.4967	0.9203	1.1416	1.1393
7	0.6477	0.9500	0.8822	1.1676	1.0490	1.0273	0.8288	1.0202	0.9540	1.1393
8	0.6477	0.9500	0.8822	1.1676	1.0490	1.0273	0.8288	1.0202	0.9540	1.1393
4-7	**0.6204**	**1.0080**	**0.9004**	**1.1067**	**1.0680**	**1.1443**	**0.8239**	**0.9748**	**0.9959**	**1.1393**

SSB At the Start of the Spawning Season - males & females (mt)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	279.268	259.256	342.256	208.742	315.150	431.623	884.910	189.900	124.471	211.490
2	4128.022	2378.125	2235.356	3229.377	2055.311	3115.612	4133.605	8333.216	1523.338	1032.841
3	4419.886	6395.164	3409.523	3502.206	5326.099	3645.748	5587.333	7435.895	14562.007	2379.669
4	5272.487	3437.366	5093.878	2609.312	2596.884	3882.623	3391.217	4721.398	6146.460	12453.578
5	5478.277	3080.370	1857.316	3013.166	1119.350	1370.345	2040.952	2040.127	2226.525	3006.943
6	1150.792	2636.628	1448.734	819.632	1282.375	401.124	618.035	619.344	1107.789	1038.018
7	1421.929	437.469	810.522	680.069	350.667	525.090	122.428	390.847	289.574	457.653
8	3554.754	1810.129	1215.290	890.438	913.095	498.430	416.568	495.246	1559.278	648.767
Tot	**25705.416**	**20434.507**	**16412.875**	**14952.941**	**13958.932**	**13870.594**	**17195.049**	**24225.974**	**27539.442**	**21228.961**

classes. The unusually strong 1987 year class accounted for the high level of SSB observed in 1990 (Figure 7). Recent recruitment, however, has been poor as the 1988-1990 year classes (≤ 5 million) are estimated to be among the poorest in the series (Tables 14 and 15).

To evaluate the precision of the final estimates, a bootstrap procedure (Efron 1982) was used to generate distributions of the 1991 fishing mortality rate and spawning stock biomass. Figures 8 and 9 show the distribution of the bootstrap estimates and a cumulative probability curve. The cumulative probability expresses the likelihood that the fishing mortality rate was greater than a given level (Figure 8) or the likelihood that spawning stock biomass was less than a given level (Figure 9) when measurement error is considered. The precision of the 1992 stock size, Q, 1991 fishing mortality, and 1991 spawning stock biomass estimates are presented in Table 16.

Coefficients of variation (CV) for the 1992 stock size estimates ranged from 27% (age 3) to 50% (age 6), and CVs for Qs among all indices ranged from 16 to 19%. The fully recruited fishing mortality for ages 4+ was reasonably well estimated (CV = 0.17). The mean bootstrap estimate of F (1.164) was slightly higher than the point estimate (1.139) from the VPA and ranged from 0.7 to 2.0 (Figure 8). $F_{20\%}$ is much lower than the lowest bootstrap estimate and F_{1991} is almost certainly above the overfishing definition mortality rate. Fishing mortality in 1990 (1.00) falls within the lower range of these bootstrap estimates for 1991. Therefore, given the amount of precision associated with the 1991 estimate, the probability that the true F_{1991} is greater than F_{1990} is about 80%.

Although the abundance estimates of individual ages in 1992 had wider variances (CV = 0.27 to 0.50), the estimate of 1991 spawning stock biomass was robust (CV = 0.13). The bootstrap mean (21,650 t) was slightly higher than the VPA point estimate (21,230) and ranged from 15,000 to 35,000 t. Current spawning stock biomass is the lowest observed in the series.

YIELD AND SPAWNING STOCK BIOMASS PER RECRUIT

Yield-per-recruit, total stock biomass per recruit, and spawning stock biomass per recruit analyses were performed using the Thompson and Bell (1934) method. Mean weights at age for application to yield per recruit were computed as the arithmetic average of catch mean weights at age (Table 4) over the 1989-1991 period. Mean weights at age for application to SSB per recruit were computed as the arithmetic average of stock mean weights at age (Table 5) over the 1989-1991 period. The maturation ogive was taken from O'Brien *et al.* (in press). To obtain the exploitation pattern for these analyses, geometric mean F at age was first computed over the period 1986-1990 from the final converged VPA results. A smoothed exploitation pattern was then obtained by dividing the F at age by the mean unweighted F for ages 4 to 7. The final exploitation pattern is as follows:

Age 1 0.0001,
Age 2 0.0347
Age 3 0.3828
Age 4+ 1.000

This pattern is similar to that obtained from a separable VPA and to that presented in the 1991 Gulf of Maine cod assessment, and was used in yield and SSB per recruit calculations. Input data and results of the yield and SSB per recruit calculations are listed in Table 17 and are illustrated in Figure 10. The yield per recruit analyses indicate that $F_{0.1} = 0.15$, $F_{max} = 0.25$, and SSB per recruit calculations indicate that $F_{20\%} = 0.36$.

PROJECTIONS FOR 1993 AND 1994

Catches and stock sizes were projected through 1993 at various levels of F and recruitment assuming a status quo F in 1992. The exploitation pattern, mean weights and maturation rates were as described above for the yield and SSB per recruit analyses. Survivors at ages 2 to 8+, taken from the final calibrated VPA, were used to start the projections in 1992. Projections were run under three recruitment options for the 1991 and 1992 year classes in 1993 and 1994: assuming these year classes were equal to the lowest previously observed (3.2 million fish at age 2); assuming these year classes were equal to the geometric mean of the 1980-1988 year classes (6.1 million); and assuming these year classes were equal to the highest previously observed (16.3 million fish at age 2).

Projections are provided over a range of F levels which includes F_{max}, $F_{20\%}$, 90% of F_{SQ}, and F_{SQ}. Input and output from the projections are given in Table 18. The assumption of status quo F in 1992 of 1.14 resulted in a catch of approximately 11,000 t in 1992. Preliminary catch

Table 15. Analysis by RCT3 ver3.1 of data from file : GMCODRCT.DAT GULF OF MAINE COD: recruits as 2-group.

Data for 4 surveys over 11 years : 1980 - 1990
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.

Yearclass = 1989

Survey/ Series	Regression Slope	Intercept	Std Error	Rsquare	No. Pts	Prediction Index Value	Predicted Value	Std Error	WAP Weights
NESP1	1.60	-1.46	1.01	.235	9	5.35	7.10	1.350	.085
NEFL1	1.64	-1.83	1.00	.238	9	3.40	3.74	2.214	.031
MASP1	1.36	-3.53	.82	.316	9	8.18	7.63	1.057	.138
MAFL1	.65	3.87	.71	.386	9	9.12	9.77	.916	.184
					VPA Mean =		8.71	.524	.562

Yearclass = 1990

Survey/ Series	Regression Slope	Intercept	Std Error	Rsquare	No. Pts	Prediction Index Value	Predicted Value	Std Error	WAP Weights
NESP1	1.60	-1.46	1.01	.235	9	5.53	7.39	1.305	.098
NEFL1	1.64	-1.83	1.00	.238	9	4.96	6.29	1.502	.074
MASP1									
MAFL1	.65	3.87	.71	.386	9	8.34	9.27	.865	.222
					VPA Mean =		8.71	.524	.606

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio
1989	4742	8.46	.39	.57	2.12
1990	5055	8.53	.41	.46	1.28

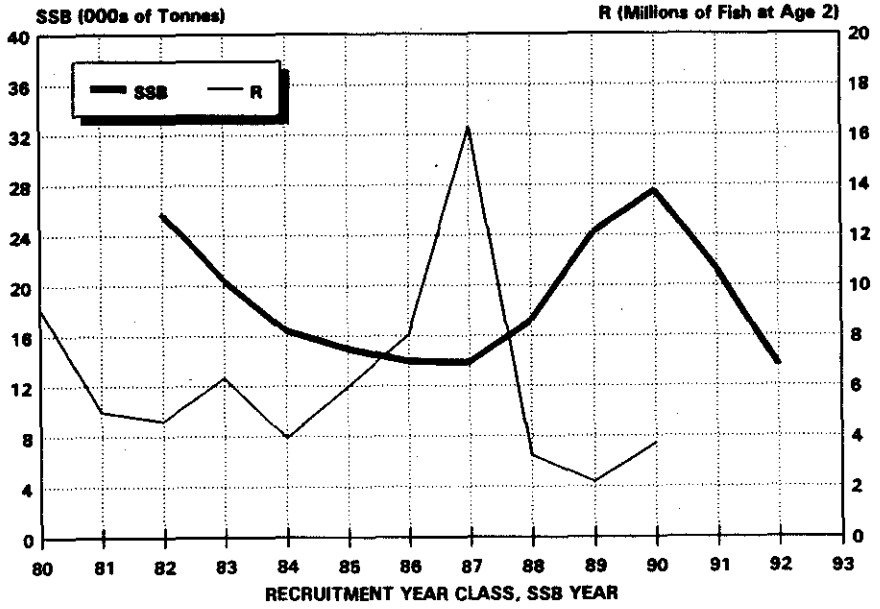

Figure 7. Trends in spawning stock biomass and recruitment for Gulf of Maine cod, 1980-1992.

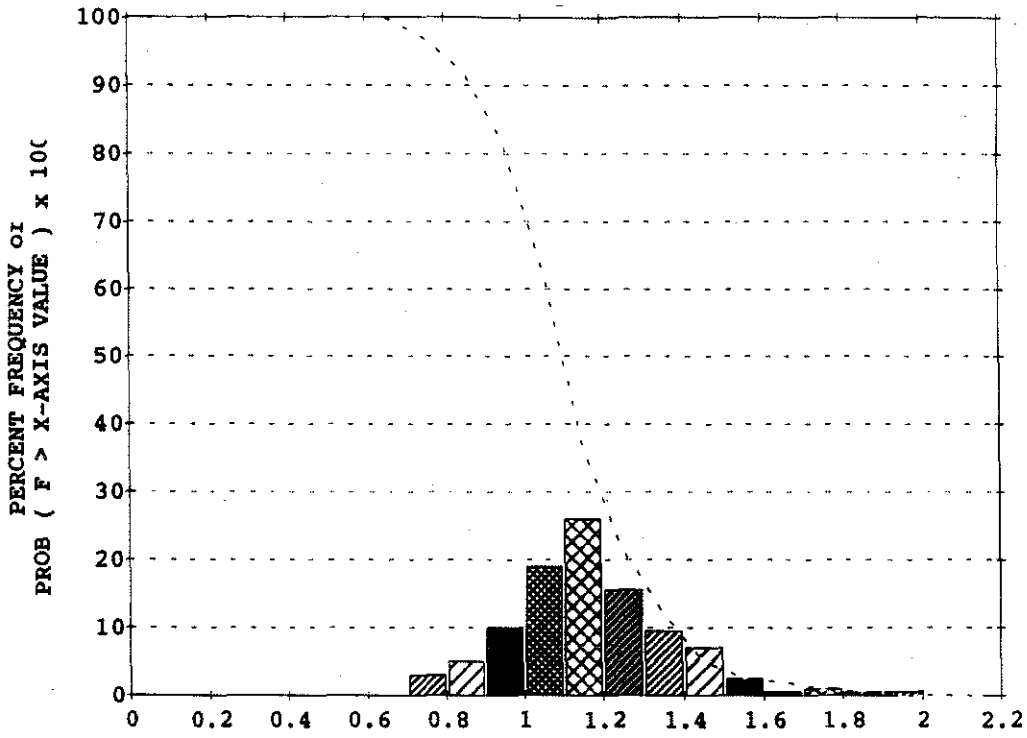

Figure 8. Precision of the estimates of the instantaneous rate of fishing mortality (F) on the fully recruited ages (Ages 4+) in 1991 for Gulf of Maine cod. The vertical bars display both the range of the estimator and the probability of individual values within that range. The dashed line gives the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

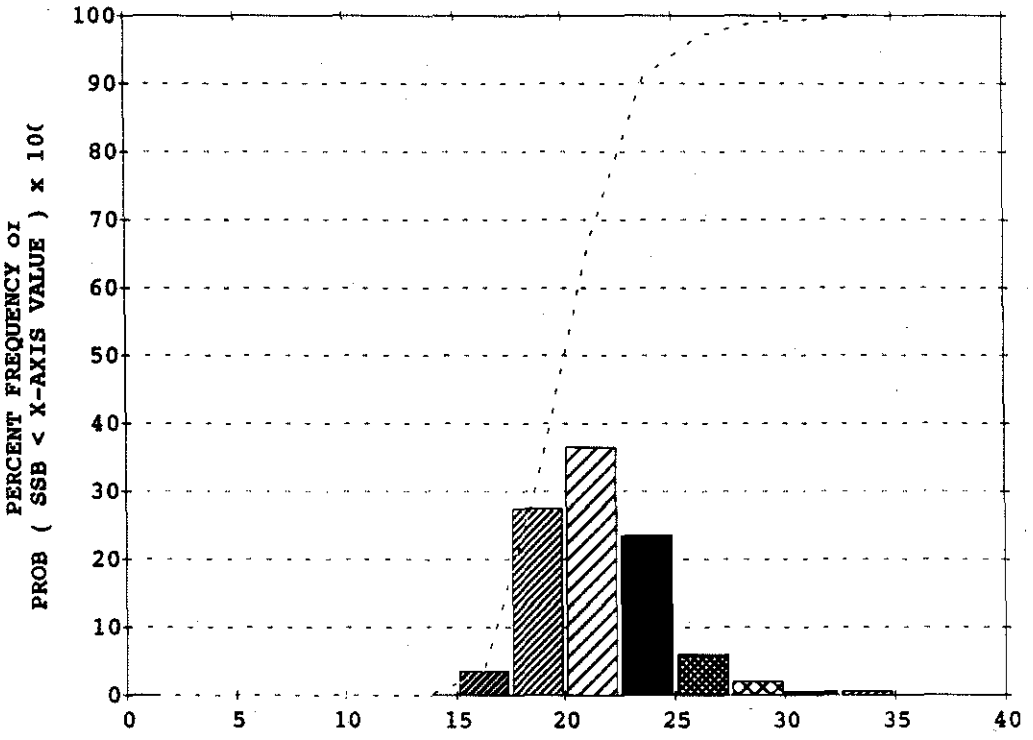

Figure 9. Precision of the estimates of spawning stock biomass at the beginning of the 1991 spawning season for Gulf of Maine cod. The vertical bars display both the range of the estimator and the probability of individual values within that range. The dashed line gives the probability that SSB is less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

Table 16. Precision estimates of the 1992 age-specific stock sizes, catchability coefficients, 1991 instantaneous fishing mortality rates (F), and 1991 spawning stock biomass (SSB) for Gulf of Maine cod. *ADAPT ESTIMATE* is from the final concensus assessment run. Standard errors, coefficients of variation (CV), and bias estimates are derived from 200 bootstrap replications. F on ages 4+ represents the fully-recruited portion of the stock.

Age-specific stock sizes (on Jan 1, 1992) estimated by ADAPT

Age	ADAPT Estimate	Bootstrap Mean	Bootstrap Std Error	CVs of ADAPT SOLN
2	3.715E3	3.858E3	1.260E3	0.34
3	1.479E3	1.531E3	4.003E2	0.27
4	1.180E3	1.250E3	3.520E2	0.30
5	2.454E3	2.546E3	9.402E2	0.38
6	2.699E2	2.960E2	1.344E2	0.50

Catchability estimates (q) for each index of abundance used in the ADAPT run re-scaled to original units.

Index	ADAPT Estimate	Bootstrap Mean	Bootstrap Std. Error	CVs of ADAPT SOLN
RVSP2	9.029E-5	9.153E-5	1.571E-5	0.17
RVSP3	1.482E-4	1.506E-4	2.431E-5	0.16
RVSP4	2.316E-4	2.342E-4	3.760E-5	0.16
RVSP5	2.948E-4	2.967E-4	5.009E-5	0.17
RVSP6	2.775E-4	2.797E-4	4.880E-5	0.18
RVFL2	7.728E-5	7.863E-5	1.339E-5	0.17
RVFL3	1.910E-4	1.920E-4	3.168E-5	0.17
RVFL4	3.395E-4	3.416E-4	5.618E-5	0.17
RVFL5	4.380E-4	4.416E-4	8.177E-5	0.19
RVFL6	6.443E-4	6.512E-4	1.158E-4	0.18
CMCE3	1.421E-5	1.432E-5	2.515E-6	0.18
CMCE4	2.287E-5	2.304E-5	4.191E-6	0.18
CMCE5	2.509E-5	2.582E-5	4.876E-6	0.19
CMCE6	2.358E-5	2.406E-5	4.134E-6	0.18
MASP2	1.309E-3	1.317E-3	2.389E-4	0.18
MASP3	7.227E-4	7.351E-4	1.325E-4	0.18
MASP4	3.500E-4	3.514E-4	6.034E-5	0.17
MAFL2	4.174E-4	4.222E-4	7.396E-5	0.18

Full vector of age-specific terminal Fs (in 1991)

Age	ADAPT Estimate	Bootstrap Mean	Bootstrap Std Error	CVs of ADAPT SOLN
1	2.436E-7	2.581E-7	8.275E-8	0.34
2	1.910E-1	1.963E-1	5.013E-2	0.26
3	5.402E-1	5.408E-1	1.137E-1	0.21
4	9.298E-1	9.583E-1	2.107E-1	0.23
5	1.349E0	1.369E0	3.359E-1	0.25
6	1.139E0	1.164E0	1.973E-1	0.17
7	1.139E0	1.164E0	1.973E-1	0.17
8	1.139E0	1.164E0	1.973E-1	0.17
4+	1.139E0	1.164E0	1.973E-1	0.17

SSB (males & females) at start of spawning season (1991)

	ADAPT Estimate	Bootstrap Mean	Bootstrap STD Error	CVs of ADAPT SOLN
	2.123E4	2.165E4	2.716E3	0.13

Table 17. Yield and spawning stock biomass per recruit estimates and input data for Gulf of Maine cod

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

GULF OF MAINE COD: Run Date: 15-12-1992; Time: 09:38:34.01

Proportion of F before spawning: .1670
Proportion of M before spawning: .1670
Natural Mortality is Constant at: .200
Initial age is: 1; Last age is: 10
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
--> B:\ASSES\GMCODYPR.DAT

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Stock
1	.0001	1.0000	.0600	.000	.814
2	.0347	1.0000	.5000	1.149	1.016
3	.3828	1.0000	.8400	1.679	1.417
4	1.0000	1.0000	.9600	2.592	2.148
5	1.0000	1.0000	1.0000	4.088	3.233
6	1.0000	1.0000	1.0000	6.609	5.345
7	1.0000	1.0000	1.0000	9.881	7.912
8	1.0000	1.0000	1.0000	12.006	10.943
9	1.0000	1.0000	1.0000	15.123	13.248
10	1.0000	1.0000	1.0000	18.000	18.000

Summary of Yield per Recruit Analysis for: Cod, Gulf of Maine -1992 ASSMT AVE WTS, FPAT AND MAT VECTORS

Slope of the Yield/Recruit Curve at F=0.00: --> 28.6006
F level at slope=1/10 of the above slope ($F_{0.1}$): ---> .151
Yield/Recruit corresponding to $F_{0.1}$: ---> 1.7125
F level to produce Maximum Yield/Recruit (F_{max}): ---> .254
Yield/Recruit corresponding to F_{max}: ---> 1.8282
F level at 20 % of Max Spawning Potential ($F_{20\%}$): ---> .356
SSB/Recruit corresponding to $F_{20\%}$: -----> 5.7994

Listing of Yield per Recruit Results for: Cod, Gulf of Maine -1992 ASSMT AVE WTS, FPAT AND MAT VECTORS

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	5.5167	31.3639	3.9054	28.9988	100.00
	.060	.13884	1.13027	4.8254	21.5648	3.2131	19.3375	66.68
	.120	.22602	1.59604	4.3923	16.0053	2.7789	13.8848	47.88
$F_{0.1}$	.151	.25961	1.71253	4.2259	14.0326	2.6119	11.9580	41.24
	.180	.28602	1.77670	4.0951	12.5612	2.4807	10.5244	36.29
	.240	.32995	1.82684	3.8782	10.2930	2.2627	8.3222	28.70
F_{max}	.254	.33833	1.82817	3.8369	9.8880	2.2211	7.9302	27.35
	.300	.36358	1.81619	3.7126	8.7285	2.0961	6.8103	23.48
$F_{20\%}$	.356	.38850	1.78139	3.5904	7.6782	1.9729	5.7994	20.00
	.360	.39022	1.77816	3.5819	7.6091	1.9644	5.7330	19.77
	.420	.41190	1.72929	3.4760	6.7832	1.8575	4.9412	17.04
	.480	.42993	1.67780	3.3882	6.1578	1.7687	4.3437	14.98
	.540	.44519	1.62774	3.3142	5.6735	1.6938	3.8822	13.39
	.600	.45830	1.58094	3.2509	5.2908	1.6296	3.5185	12.13
	.660	.46970	1.53812	3.1960	4.9831	1.5738	3.2266	11.13
	.720	.47974	1.49937	3.1479	4.7316	1.5248	2.9885	10.31
	.780	.48866	1.46454	3.1053	4.5232	1.4814	2.7914	9.63
	.840	.49664	1.43331	3.0674	4.3482	1.4426	2.6260	9.06
	.900	.50385	1.40533	3.0332	4.1995	1.4077	2.4856	8.57
	.960	.51039	1.38024	3.0023	4.0718	1.3760	2.3650	8.16
	1.020	.51637	1.35772	2.9742	3.9611	1.3471	2.2605	7.80
	1.080	.52187	1.33746	2.9485	3.8642	1.3207	2.1690	7.48
	1.140	.52694	1.31918	2.9248	3.7787	1.2963	2.0883	7.20
	1.200	.53164	1.30264	2.9029	3.7028	1.2737	2.0166	6.95

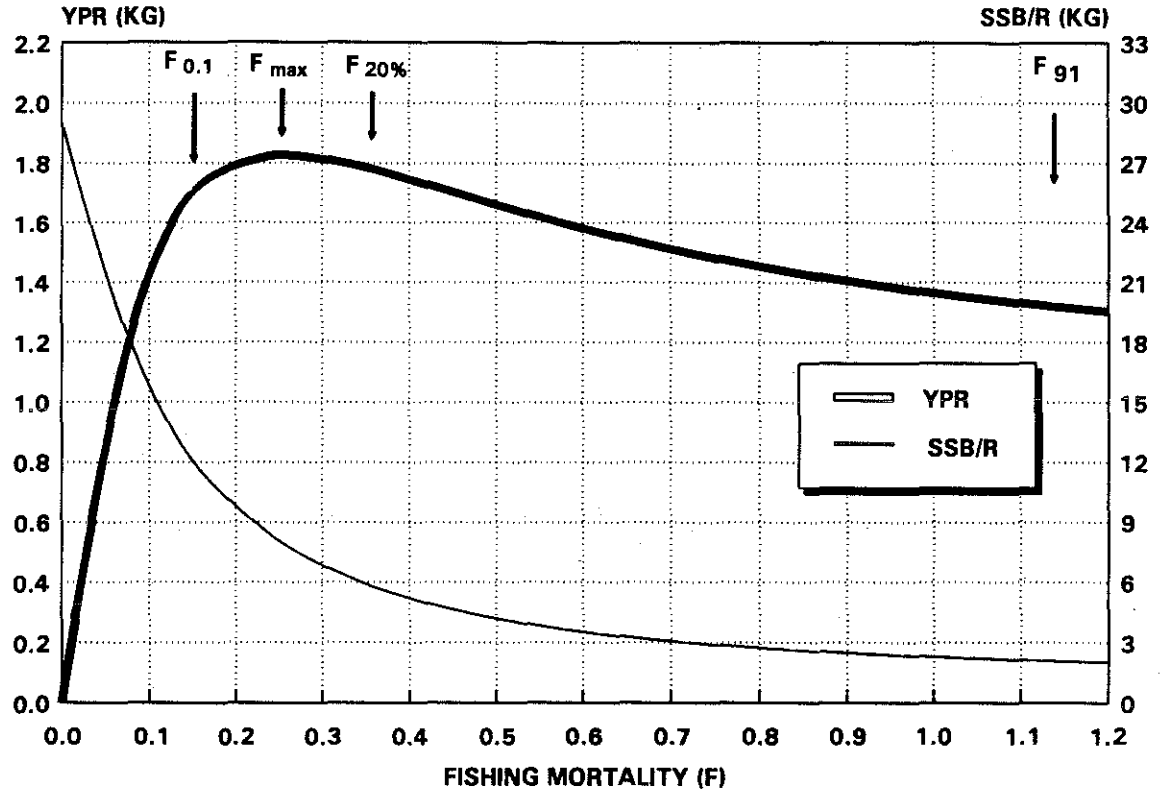

Figure 10. Yield per recruit (YPR) and spawning stock biomass per recruit (SSB/R) for Gulf of Maine cod.

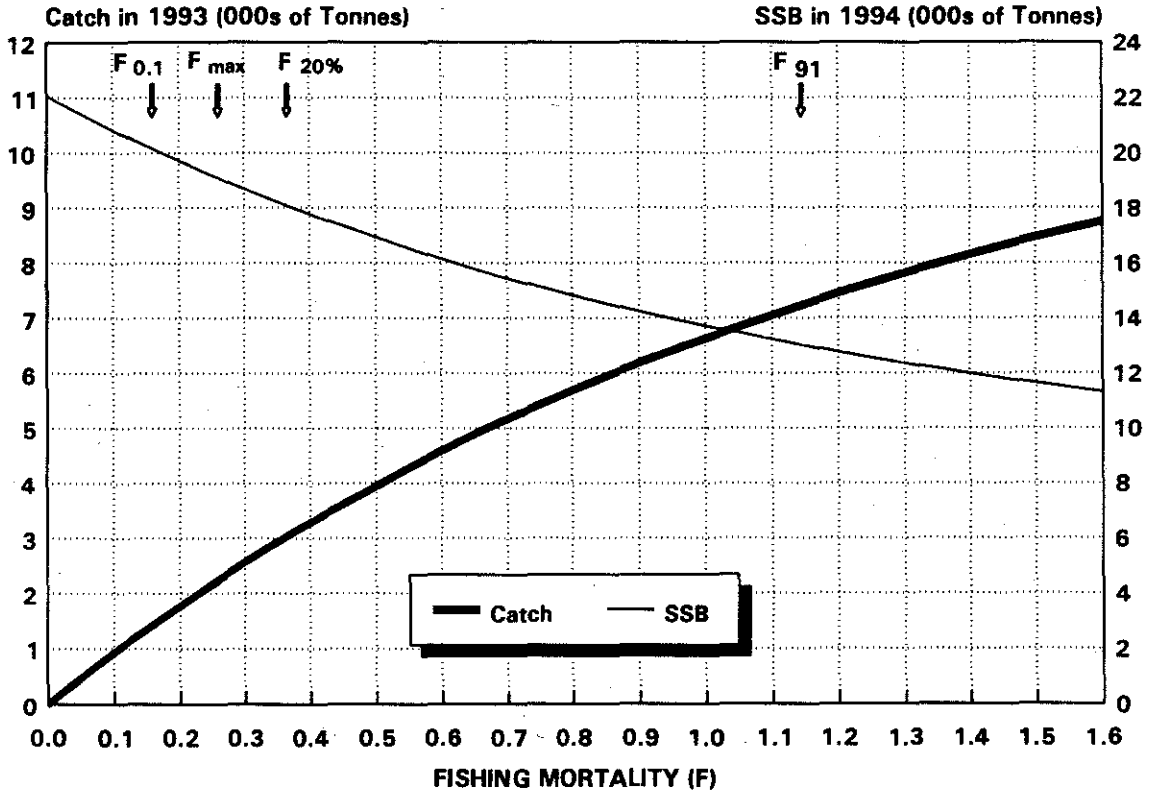

Figure 11. Predicted catches in 1993 and spawning stock biomasses in 1994 of Gulf of Maine cod over a range of fishing mortalities in 1993 from F=0 to F=1.6.

Table 18. Stock biomass and catch projections, starting conditions and input data for Gulf of Maine cod

The NEFC/PDB Catch and Stock Size Prediction Program - PDBPRED
GULF OF MAINE COD: Run Date: 22-11-1992; Time: 15:48:24.07

Input for Projections:

Number of Years: 3; Initial Year: 1992; Final Year: 1994
Number of Ages : 7; Age at Recruitment: 2; Last Age: 8
Natural Mortality is assumed Constant over time at: .200
Proportion of F before spawning: .1670
Proportion of M before spawning: .1670
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file
===>B:\ASSES\GMCODPRD.DAT

Year-specific Input data for Projection # 1

	Year	Recruits at Age 2	Reference F	Natural Mortality	Target Catch
Low					
	1992	3715.	1.140	.200	N/A
	1993	3247.	1.140	.200	N/A
	1994	3247.	1.140	.200	N/A
Ave					
	1992	3715.	1.140	.200	N/A
	1993	6188.	1.140	.200	N/A
	1994	6188.	1.140	.200	N/A
High					
	1992	3715.	1.140	.200	N/A
	1993	16328.	1.140	.200	N/A
	1994	16328.	1.140	.200	N/A

Age-specific Input data for Projection # 1

Age	Stock Size in 1992	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights	
					Catch	Stock
2	3715.	.0330	1.0000	.5000	1.149	1.016
3	1479.	.3796	1.0000	.8400	1.679	1.417
4	1180.	1.0000	1.0000	.9600	2.592	2.148
5	2454.	1.0000	1.0000	1.0000	4.088	3.233
6	270.	1.0000	1.0000	1.0000	6.609	5.345
7	61.	1.0000	1.0000	1.0000	9.881	7.912
8+	33.	1.0000	1.0000	1.0000	15.006	14.000

Projections for 1993 and 1994 under various recruitment and F levels assuming: F92=F91=1.14

1993-1994 Recruitment Level	1992			1993			1994
	F	Landings	SSB	F	Landings	SSB	SSB
Low = 3247	1.14	10907	13595	F_{max}=0.25	2197	11361	14988
	1.14	10970	13595	$F_{20\%}$=0.36	2985	11224	13996
	1.14	10970	13595	$_{90\%}F_{SQ}$=1.03	6670	10411	9607
	1.14	10970	13595	F_{SQ}=1.14	7111	10285	9113
Ave = 6188	1.14	10970	13595	F_{max}=0.25	2223	12804	19136
	1.14	10970	13595	$F_{20\%}$=0.36	3021	12666	18115
	1.14	10970	13595	$_{90\%}F_{SQ}$=1.03	6755	11852	13573
	1.14	10970	13595	F_{SQ}=1.14	7224	11720	13032
High = 16328	1.14	10970	13595	F_{max}=0.25	2311	17778	34437
	1.14	10970	13595	$F_{20\%}$=0.36	3146	17638	32319
	1.14	10970	13595	$_{90\%}F_{SQ}$=1.03	7125	16801	27161
	1.14	10970	13595	F_{SQ}=1.14	7615	16671	26546

statistics indicate that 1992 Gulf of Maine cod landings will be in the range of 11,000 mt, considerably lower than in 1991. Thus the assumption of status quo F in 1992 appears reasonable. Under average recruitment in 1993, continued fishing at F = 1.14 will result in a projected catch of about 7,000 t and will lead to further reductions in SSB from 21,200 t in 1991 to about 11,700 t in 1993 and 13,000 t in 1994 (Figure 11).

CONCLUSIONS

The Gulf of Maine cod stock is presently at a low biomass level and is over exploited. Fishing mortality in 1991 increased to a record-high while spawning stock biomass (SSB) in 1992 declined to a record-low. Accounting for the estimation uncertainty associated with the 1991 SSB (21,200 mt) and 1991 F (1.14) estimates, there is an 80% probability that the 1991 SSB lies between 17,000 mt and 24,000 mt, and that the 1991 F lies between 0.87 and 1.38. This further implies a 90% probability that the 1991 F is greater than 0.87, or about 2.5 times greater than the overfishing definition ($F_{20\%}$=0.36).

Continued fishing at current levels of fishing mortality (*i.e.*, F=1.14) will lead to catches in 1993 declining to their lowest level since 1973. 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. Assuming average recruitment in 1993 and 1994, a 70% reduction in F to $F_{20\%}$ in 1993 would increase SSB in 1994 to near the 1982-1991 average and enhance the prospects for a sustained recovery. At $F_{20\%}$, spawning stock biomass per recruit would nearly triple over the long term. The spawning stock biomass in 1994 will no longer be dominated by the 1987 year class, which will only constitute 8% of the SSB. If recruitment in 1993 and 1994 is average or below average, SSB in 1994 will remain at record-low levels.

ACKNOWLEDGEMENTS

We express our appreciation to Ray Conser for his considerable efforts in the development and implementation of the algorithms used in the ADAPT and bootstrapping procedures.

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Appendix 1

Appendix 1:Table 1. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine, 1963 - 1992 [a,b,c,d]

	Age Group											Totals						Str.Mean
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	Wgt per tow
Spring																		
1968	0.082	0.393	0.791	0.902	0.542	0.345	0.133	0.083	0.071	0.038	0.106	3.486	3.404	3.011	2.220	1.318	0.776	11.06
1969	0.000	0.000	0.023	0.197	0.564	0.517	0.406	0.164	0.092	0.057	0.065	2.085	2.085	2.085	2.062	1.865	1.301	8.15
1970	0.000	0.102	0.079	0.035	0.060	0.175	0.299	0.394	0.048	0.038	0.184	1.414	1.414	1.312	1.233	1.198	1.138	6.83
1971	0.000	0.016	0.091	0.070	0.187	0.031	0.053	0.192	0.132	0.099	0.046	0.917	0.917	0.901	0.810	0.740	0.553	4.31
1972	0.000	0.226	0.098	0.333	0.126	0.128	0.023	0.068	0.065	0.147	0.105	1.319	1.319	1.093	0.995	0.662	0.536	4.96
1973	0.000	0.022	2.724	0.581	0.397	0.224	0.125	0.061	0.143	0.161	0.392	4.830	4.830	4.808	2.084	1.503	1.106	11.60
1974	0.000	0.305	0.036	0.871	0.211	0.142	0.073	0.031	0.031	0.013	0.149	1.862	1.862	1.557	1.521	0.650	0.439	4.59
1975	0.004	0.060	0.448	0.068	0.683	0.166	0.071	0.003	0.003	0.012	0.092	1.610	1.606	1.546	1.098	1.030	0.347	3.72
1976	0.000	0.027	0.195	0.672	0.098	0.575	0.055	0.069	0.042	0.000	0.047	1.780	1.780	1.753	1.558	0.886	0.788	4.66
1977	0.000	0.016	0.191	0.334	1.278	0.070	0.507	0.004	0.065	0.000	0.024	2.489	2.489	2.473	2.282	1.948	0.670	5.27
1978	0.000	0.022	0.067	0.183	0.223	0.491	0.048	0.205	0.005	0.068	0.005	1.317	1.317	1.295	1.228	1.045	0.822	4.75
1979	0.028	0.343	1.045	0.136	0.320	0.257	0.439	0.038	0.091	0.008	0.034	2.739	2.711	2.368	1.323	1.187	0.867	5.86
1980	0.057	0.057	0.357	0.278	0.100	0.339	0.194	0.246	0.000	0.105	0.011	1.744	1.687	1.630	1.273	0.995	0.895	5.69
1981	0.000	0.823	0.537	0.800	0.987	0.266	0.233	0.089	0.126	0.086	0.000	3.947	3.947	3.124	2.587	1.787	0.800	9.94
1982	0.012	0.273	0.827	0.419	0.563	0.701	0.095	0.088	0.000	0.034	0.032	3.044	3.032	2.759	1.932	1.513	0.950	7.94
1983	0.008	0.401	0.627	0.534	0.411	0.229	0.116	0.059	0.000	0.058	0.065	2.508	2.500	2.099	1.472	0.938	0.527	6.48
1984	0.000	0.097	0.662	0.735	0.475	0.122	0.034	0.037	0.019	0.000	0.000	2.181	2.181	2.084	1.422	0.687	0.212	3.60
1985	0.000	0.028	0.238	0.622	0.665	0.677	0.095	0.114	0.052	0.000	0.026	2.517	2.517	2.489	2.251	1.629	0.964	7.65
1986	0.000	0.417	0.330	0.647	0.387	0.074	0.046	0.027	0.011	0.000	0.018	1.957	1.957	1.540	1.210	0.563	0.176	3.60
1987	0.000	0.049	0.638	0.486	0.300	0.128	0.011	0.045	0.011	0.000	0.014	1.682	1.682	1.633	0.995	0.509	0.209	3.01
1988	0.029	0.663	1.053	0.633	0.355	0.217	0.087	0.063	0.000	0.027	0.000	3.127	3.098	2.435	1.382	0.749	0.394	3.30
1989	0.000	0.029	0.822	1.000	0.800	0.114	0.097	0.000	0.000	0.000	0.000	2.862	2.862	2.833	2.011	1.011	0.211	3.78
1990	0.000	0.000	0.241	1.680	0.794	0.211	0.041	0.023	0.000	0.000	0.000	2.990	2.990	2.990	2.749	1.069	0.275	4.59
1991	0.000	0.054	0.265	0.449	1.870	0.339	0.030	0.023	0.000	0.000	0.000	3.030	3.030	2.976	2.711	2.262	0.392	4.31
1992	0.000	0.050	0.250	0.220	0.260	1.320	0.210	0.070	0.000	0.010	0.000	2.390	2.390	2.340	2.090	1.870	1.610	8.66

[a] Spring and autumn: Strata 26-30 and 36-40.

[b] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

[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] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments have been made to the catch per tow data for these gear differences.

Appendix 1:Table 1 (Continued). [a,b,c,d]

Year	Age Group 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+	Str.Mean Wgt per tow
Autumn																		
1963	0.032	0.416	0.865	0.803	0.544	0.371	0.344	0.192	0.117	0.061	0.048	3.793	3.761	3.345	2.480	1.677	1.133	11.08
1964	0.000	0.059	0.078	0.302	0.549	0.547	0.502	0.239	0.152	0.073	0.065	2.566	2.566	2.507	2.429	2.127	1.578	14.07
1965	0.001	0.545	0.564	0.528	0.481	0.318	0.240	0.109	0.051	0.028	0.016	2.881	2.880	2.335	1.771	1.243	0.762	7.41
1966	0.109	0.131	0.410	0.447	0.460	0.358	0.283	0.123	0.050	0.031	0.023	2.425	2.316	2.185	1.775	1.328	0.868	7.97
1967	0.008	0.083	0.138	0.368	0.430	0.246	0.172	0.104	0.045	0.026	0.022	1.642	1.634	1.551	1.413	1.045	0.615	5.70
1968	0.008	0.023	0.115	0.461	0.805	0.624	0.402	0.167	0.100	0.046	0.061	2.812	2.804	2.781	2.666	2.205	1.400	12.00
1969	0.010	0.038	0.079	0.227	0.404	0.354	0.299	0.141	0.093	0.083	0.040	1.768	1.758	1.720	1.641	1.414	1.010	9.49
1970	0.476	0.603	0.170	0.353	0.211	0.313	0.271	0.506	0.084	0.060	0.094	3.141	2.665	2.062	1.892	1.539	1.328	10.14
1971	0.863	0.114	0.153	0.135	0.383	0.295	0.278	0.163	0.204	0.128	0.082	2.798	1.935	1.821	1.668	1.533	1.150	10.20
1972	0.020	3.576	0.780	0.978	0.150	0.060	0.110	0.025	0.102	0.155	0.010	5.966	5.946	2.370	1.590	0.612	0.462	8.00
1973	0.408	0.210	1.393	0.089	0.325	0.136	0.050	0.018	0.033	0.108	0.087	2.857	2.449	2.239	0.846	0.757	0.432	5.39
1974	0.181	0.720	0.121	1.118	0.187	0.230	0.050	0.008	0.008	0.027	0.127	2.777	2.596	1.876	1.755	0.637	0.450	5.54
1975	0.030	0.094	1.966	0.086	1.510	0.163	0.070	0.011	0.002	0.002	0.008	3.942	3.912	3.818	1.852	1.766	0.256	5.32
1976	0.000	0.156	0.134	0.405	0.064	0.492	0.037	0.061	0.000	0.010	0.020	1.379	1.379	1.223	1.089	0.684	0.620	4.16
1977	0.000	0.018	0.291	0.446	0.937	0.123	0.481	0.031	0.079	0.018	0.078	2.502	2.502	2.484	2.193	1.747	0.810	9.42
1978	0.202	1.111	0.301	0.907	0.532	1.160	0.091	0.264	0.007	0.049	0.041	4.665	4.463	3.352	3.051	2.144	1.612	11.88
1979	0.003	0.236	0.381	0.104	0.536	0.251	0.501	0.033	0.138	0.000	0.053	2.236	2.233	1.997	1.616	1.512	0.976	10.83
1980	0.022	1.026	2.111	1.423	0.403	0.188	0.272	0.168	0.024	0.015	0.058	5.710	5.688	4.662	2.551	1.128	0.725	13.09
1981	0.008	0.397	0.245	0.352	0.304	0.057	0.076	0.024	0.069	0.000	0.018	1.550	1.542	1.145	0.900	0.548	0.244	4.97
1982	0.000	0.449	2.014	1.585	0.748	0.159	0.000	0.025	0.000	0.000	0.000	4.980	4.980	4.531	2.517	0.932	0.184	9.92
1983	0.029	1.064	0.626	0.546	0.089	0.169	0.126	0.000	0.000	0.000	0.058	2.707	2.678	1.614	0.988	0.442	0.353	5.44
1984	0.028	0.246	0.270	0.362	0.256	0.141	0.131	0.057	0.000	0.020	0.042	1.553	1.525	1.279	1.009	0.647	0.391	5.44
1985	0.266	0.378	0.910	0.763	0.209	0.218	0.074	0.000	0.034	0.021	0.049	2.922	2.656	2.278	1.368	0.605	0.396	8.49
1986	0.000	0.301	0.490	0.654	0.333	0.086	0.042	0.000	0.000	0.024	0.021	1.951	1.951	1.650	1.160	0.506	0.173	5.10
1987	0.138	0.599	1.324	0.600	0.257	0.061	0.000	0.000	0.000	0.000	0.000	2.979	2.841	2.242	0.918	0.318	0.061	3.41
1988	0.000	1.951	2.245	0.960	0.528	0.110	0.076	0.033	0.000	0.000	0.000	5.903	5.903	3.952	1.707	0.747	0.219	6.61
1989	0.000	0.526	3.026	1.717	0.372	0.220	0.018	0.000	0.000	0.011	0.000	5.890	5.890	5.364	2.338	0.621	0.249	6.84
1990	0.008	0.037	0.464	2.080	0.788	0.352	0.036	0.013	0.000	0.000	0.000	3.778	3.770	3.733	3.269	1.189	0.401	7.33
1991	0.010	0.180	0.180	0.280	0.800	0.100	0.000	0.030	0.000	0.000	0.000	1.580	1.570	1.390	1.210	0.930	0.130	4.15
1992												1.277						2.13

[a] Spring and autumn:Strata 26-30 and 36-40.

[b] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

[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] During 1963-1984, BMV oval doors were used in spring and autumn surveys; since 1985, Portuguese polyvalent doors have been used in both surveys. No adjustments have been made to the catch per tow data for these gear differences.

Appendix 1: Table 2 . Standardized [for both door and gear changes] stratified mean number per tow at age and standardized stratified mean weight (kg) per tow of Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys in the Gulf of Maine, 1963-1992. [a,b]

	Age Group											Totals						Str.Mean Wgt per tow
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	
												Spring [c,d,e]						
1968	0.128	0.613	1.234	1.407	0.846	0.538	0.207	0.129	0.111	0.059	0.165	5.438	5.310	4.697	3.463	2.056	1.211	17.92
1969	0.000	0.000	0.036	0.307	0.880	0.807	0.633	0.256	0.144	0.089	0.101	3.253	3.253	3.253	3.217	2.909	2.030	13.20
1970	0.000	0.159	0.123	0.055	0.094	0.273	0.466	0.615	0.075	0.059	0.287	2.206	2.206	2.047	1.923	1.869	1.775	11.06
1971	0.000	0.025	0.142	0.109	0.292	0.048	0.083	0.300	0.206	0.154	0.072	1.431	1.431	1.406	1.264	1.154	0.863	6.98
1972	0.000	0.353	0.153	0.519	0.197	0.200	0.036	0.106	0.101	0.229	0.164	2.058	2.058	1.705	1.552	1.033	0.836	8.04
1973	0.000	0.034	4.249	0.906	0.619	0.349	0.195	0.095	0.223	0.251	0.612	7.535	7.535	7.500	3.251	2.345	1.725	18.79
1974	0.000	0.476	0.056	1.359	0.329	0.222	0.114	0.048	0.048	0.020	0.232	2.905	2.905	2.429	2.373	1.014	0.685	7.44
1975	0.006	0.094	0.699	0.106	1.065	0.259	0.111	0.005	0.005	0.019	0.144	2.512	2.505	2.412	1.713	1.607	0.541	6.03
1976	0.000	0.042	0.304	1.048	0.153	0.897	0.086	0.108	0.066	0.000	0.073	2.777	2.777	2.735	2.430	1.382	1.229	7.55
1977	0.000	0.025	0.298	0.521	1.994	0.109	0.791	0.006	0.101	0.000	0.037	3.883	3.883	3.858	3.560	3.039	1.045	8.54
1978	0.000	0.034	0.105	0.285	0.348	0.766	0.075	0.320	0.008	0.106	0.008	2.055	2.055	2.020	1.916	1.630	1.282	7.70
1979	0.044	0.535	1.630	0.212	0.499	0.401	0.685	0.059	0.142	0.012	0.053	4.273	4.229	3.694	2.064	1.852	1.353	9.49
1980	0.070	0.070	0.440	0.343	0.123	0.418	0.239	0.303	0.000	0.129	0.014	2.149	2.079	2.009	1.569	1.226	1.103	6.18
1981	0.000	1.014	0.662	0.986	1.216	0.328	0.287	0.110	0.155	0.106	0.000	4.864	4.864	3.850	3.188	2.202	0.986	10.79
1982	0.015	0.336	1.019	0.516	0.694	0.864	0.117	0.108	0.000	0.042	0.039	3.751	3.737	3.400	2.381	1.865	1.171	8.62
1983	0.012	0.626	0.978	0.833	0.641	0.357	0.181	0.092	0.000	0.090	0.101	3.912	3.900	3.274	2.296	1.463	0.822	10.50
1984	0.000	0.151	1.033	1.147	0.741	0.190	0.053	0.058	0.030	0.000	0.000	3.402	3.402	3.251	2.218	1.072	0.331	5.83
1985	0.000	0.028	0.238	0.622	0.665	0.677	0.095	0.114	0.052	0.000	0.026	2.517	2.517	2.489	2.251	1.629	0.964	7.65
1986	0.000	0.417	0.330	0.647	0.387	0.074	0.046	0.027	0.011	0.000	0.018	1.957	1.957	1.540	1.210	0.563	0.176	3.60
1987	0.000	0.049	0.638	0.486	0.300	0.128	0.011	0.045	0.011	0.000	0.014	1.682	1.682	1.633	0.995	0.509	0.209	3.01
1988	0.029	0.663	1.053	0.633	0.355	0.217	0.087	0.063	0.000	0.027	0.000	3.127	3.098	2.435	1.382	0.749	0.394	3.30
1989	0.000	0.023	0.649	0.790	0.632	0.090	0.077	0.000	0.000	0.000	0.000	2.261	2.261	2.238	1.589	0.799	0.167	2.53
1990	0.000	0.000	0.190	1.327	0.627	0.167	0.032	0.018	0.000	0.000	0.000	2.362	2.362	2.362	2.172	0.845	0.217	3.08
1991	0.000	0.043	0.209	0.355	1.477	0.268	0.024	0.018	0.000	0.000	0.000	2.394	2.394	2.351	2.142	1.787	0.310	2.89
1992	0.000	0.050	0.250	0.220	0.260	1.320	0.210	0.070	0.000	0.010	0.000	2.390	2.390	2.340	2.090	1.870	1.610	8.66

[a] **Spring and autumn: Strata 26-30 and 36-40.**

[b] **Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.**

[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 differences.**

[d] **During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse 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).**

[e] **In the Gulf of Maine, spring surveys during 1980-1982 and 1989-1991 and autumn surveys during 1977-1978, 1980, 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).**

Appendix 1: Table 2. Continued.[a,b,c]

Year	Age Group											Totals						Str.Mean Wgt per tow
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	
Autumn [d,e]																		
1963	0.050	0.649	1.349	1.253	0.849	0.579	0.537	0.300	0.183	0.095	0.075	5.917	5.867	5.218	3.869	2.616	1.767	17.95
1964	0.000	0.092	0.122	0.471	0.856	0.853	0.783	0.373	0.237	0.114	0.101	4.003	4.003	3.911	3.789	3.318	2.462	22.79
1965	0.002	0.850	0.880	0.824	0.750	0.496	0.374	0.170	0.080	0.044	0.025	4.494	4.493	3.643	2.763	1.939	1.189	12.00
1966	0.170	0.204	0.640	0.697	0.718	0.558	0.441	0.192	0.078	0.048	0.036	3.783	3.613	3.409	2.769	2.072	1.354	12.91
1967	0.012	0.129	0.215	0.574	0.671	0.384	0.268	0.162	0.070	0.041	0.034	2.562	2.549	2.420	2.204	1.630	0.959	9.23
1968	0.012	0.036	0.179	0.719	1.256	0.973	0.627	0.261	0.156	0.072	0.095	4.387	4.374	4.338	4.159	3.440	2.184	19.44
1969	0.016	0.059	0.123	0.354	0.630	0.552	0.466	0.220	0.145	0.129	0.062	2.758	2.742	2.683	2.560	2.206	1.576	15.37
1970	0.743	0.941	0.265	0.551	0.329	0.488	0.423	0.789	0.131	0.094	0.147	4.900	4.157	3.217	2.952	2.401	2.072	16.43
1971	1.346	0.178	0.239	0.211	0.597	0.460	0.434	0.254	0.318	0.200	0.128	4.365	3.019	2.841	2.602	2.391	1.794	16.52
1972	0.031	5.579	1.217	1.526	0.234	0.094	0.172	0.039	0.159	0.242	0.016	9.307	9.276	3.697	2.480	0.955	0.721	12.96
1973	0.636	0.328	2.173	0.139	0.507	0.212	0.078	0.028	0.051	0.168	0.136	4.457	3.820	3.493	1.320	1.181	0.674	8.73
1974	0.282	1.123	0.189	1.744	0.292	0.359	0.078	0.012	0.012	0.042	0.198	4.332	4.050	2.927	2.738	0.994	0.702	8.97
1975	0.047	0.147	3.067	0.134	2.356	0.254	0.109	0.017	0.003	0.003	0.012	6.150	6.103	5.956	2.889	2.755	0.399	8.62
1976	0.000	0.243	0.209	0.632	0.100	0.768	0.058	0.095	0.000	0.016	0.031	2.151	2.151	1.908	1.699	1.067	0.967	6.74
1977	0.000	0.022	0.359	0.550	1.155	0.152	0.593	0.038	0.097	0.022	0.096	3.083	3.083	3.061	2.703	2.153	0.998	10.22
1978	0.249	1.369	0.371	1.118	0.656	1.430	0.112	0.325	0.009	0.060	0.051	5.749	5.500	4.131	3.760	2.642	1.987	12.89
1979	0.005	0.368	0.594	0.162	0.836	0.392	0.782	0.051	0.215	0.000	0.083	3.488	3.483	3.115	2.521	2.359	1.523	17.54
1980	0.027	1.264	2.602	1.754	0.497	0.232	0.335	0.207	0.030	0.018	0.071	7.037	7.010	5.745	3.144	1.390	0.893	14.21
1981	0.012	0.619	0.382	0.549	0.474	0.089	0.119	0.037	0.108	0.000	0.028	2.418	2.406	1.786	1.404	0.855	0.381	8.05
1982	0.000	0.700	3.142	2.473	1.167	0.248	0.000	0.039	0.000	0.000	0.000	7.769	7.769	7.068	3.927	1.454	0.287	16.07
1983	0.045	1.660	0.977	0.852	0.139	0.264	0.197	0.000	0.000	0.000	0.090	4.223	4.178	2.518	1.541	0.690	0.551	8.81
1984	0.044	0.384	0.421	0.565	0.399	0.220	0.204	0.089	0.000	0.031	0.066	2.423	2.379	1.995	1.574	1.009	0.610	8.81
1985	0.266	0.378	0.910	0.763	0.209	0.218	0.074	0.000	0.034	0.021	0.049	2.922	2.656	2.278	1.368	0.605	0.396	8.49
1986	0.000	0.301	0.490	0.654	0.333	0.086	0.042	0.000	0.000	0.024	0.021	1.951	1.951	1.650	1.160	0.506	0.173	5.10
1987	0.138	0.599	1.324	0.600	0.257	0.061	0.000	0.000	0.000	0.000	0.000	2.979	2.841	2.242	0.918	0.318	0.061	3.41
1988	0.000	1.951	2.245	0.960	0.528	0.110	0.076	0.033	0.000	0.000	0.000	5.903	5.903	3.952	1.707	0.747	0.219	6.61
1989	0.000	0.416	2.391	1.356	0.294	0.174	0.014	0.000	0.000	0.009	0.000	4.653	4.653	4.238	1.847	0.491	0.197	4.58
1990	0.006	0.029	0.367	1.643	0.623	0.278	0.028	0.010	0.000	0.000	0.000	2.985	2.978	2.949	2.583	0.939	0.317	4.91
1991	0.008	0.142	0.142	0.221	0.632	0.079	0.000	0.024	0.000	0.000	0.000	1.248	1.240	1.098	0.956	0.735	0.103	2.78
1992												1.277						2.13

[a] **Spring and autumn: Strata 26-30 and 36-40.**

[b] **Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.**

[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 differences.**

[d] **During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985, Portugeuse 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).**

[e] **In the Gulf of Maine, spring surveys during 1980-1982 and 1989-1991 and autumn surveys during 1977-1978, 1980, 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).**

Appendix 1: Table 3. Stratified mean catch per tow at age in numbers and stratified mean weight per tow (kg) of Atlantic cod in State of Massachusetts inshore spring and autumn bottom trawl surveys in territorial waters in the Gulf of Maine (Massachusetts Regions 4-5), 1978-1992

Year	Age Group											Totals				Stratified Mean Wt (kg)
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	
Gulf of Maine Area (Massachusetts Regions 4-5)[1]																
Spring																
1978	21.965	12.784	4.162	4.572	0.872	1.028	0.000	0.000	0.023	0.000	0.000	45.406	23.441	10.657	6.495	12.16
1979	56.393	36.630	2.581	1.533	4.659	1.995	0.183	0.000	0.000	0.000	0.069	104.043	47.650	11.020	8.439	20.53
1980	8.156	50.311	12.679	0.971	0.745	0.737	0.080	0.214	0.000	0.025	0.000	73.918	65.762	15.451	2.772	17.71
1981	19.753	24.794	23.884	3.122	1.279	0.041	0.146	0.022	0.022	0.000	0.000	73.063	53.310	28.516	4.632	21.79
1982	1.489	16.235	7.060	3.418	1.147	0.232	0.011	0.057	0.045	0.000	0.000	29.694	28.205	11.970	4.910	13.42
1983	0.453	27.703	18.572	5.331	0.501	1.221	0.142	0.022	0.000	0.000	0.000	53.945	53.492	25.789	7.217	19.77
1984	0.206	2.896	5.408	2.271	0.865	0.138	0.162	0.000	0.000	0.000	0.000	11.946	11.740	8.844	3.436	8.63
1985	0.793	2.711	3.822	2.794	0.692	0.000	0.000	0.000	0.000	0.000	0.000	10.812	10.019	7.308	3.486	6.42
1986	0.957	19.960	3.222	0.887	0.426	0.090	0.019	0.000	0.000	0.000	0.000	25.561	24.604	4.644	1.422	7.77
1987	0.659	8.590	6.997	2.268	0.257	0.147	0.048	0.000	0.000	0.087	0.000	19.053	18.394	9.804	2.807	9.59
1988	1.595	11.841	11.356	2.511	1.370	0.000	0.039	0.000	0.000	0.000	0.000	28.712	27.117	15.276	3.920	9.66
1989	0.157	20.679	25.260	6.580	0.458	0.106	0.124	0.000	0.000	0.000	0.000	53.364	53.207	32.528	7.268	18.26
1990	4.10	6.33	6.89	17.77	2.64	0.18	0.05	0.02	0.000	0.000	0.000	37.980	33.88	27.55	20.66	19.51
1991	0.32	5.88	3.56	2.54	5.03	0.36	0.000	0.000	0.000	0.000	0.000	17.69	17.37	11.49	7.93	11.37
1992												19.888				10.11
Autumn																
1978	151.533	2.082	0.000	0.120	0.140	0.318	0.000	0.080	0.000	0.000	0.000	154.273	2.740	0.658	0.658	3.02
1979	4.933	3.430	0.042	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	8.431	3.498	0.068	0.026	0.99
1980	5.680	8.834	0.052	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	14.616	8.936	0.102	0.050	1.57
1981	2.018	5.652	7.290	0.729	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.689	13.671	8.019	0.729	6.65
1982	4.667	2.346	1.005	0.060	0.050	0.000	0.000	0.000	0.000	0.000	0.000	8.128	3.461	1.115	0.110	1.35
1983	1.308	0.651	0.100	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.072	0.764	0.113	0.013	0.18
1984	12.296	0.344	0.022	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.675	0.379	0.035	0.013	0.18
1985	2.832	0.419	0.018	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.279	0.447	0.028	0.010	0.09
1986	2.478	1.150	0.833	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.000	4.528	2.050	0.900	0.067	0.55
1987	389.584	2.386	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	391.990	2.406	0.020	0.000	0.45
1988	4.571	20.490	0.679	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	25.740	21.169	0.679	0.000	1.57
1989	2.971	2.700	0.350	0.210	0.185	0.000	0.000	0.000	0.000	0.000	0.000	6.416	3.445	0.745	0.395	1.27
1990	9.37	9.13	1.74	0.31	0.06	0.03	0.000	0.000	0.000	0.000	0.000	20.638	11.27	2.14	0.40	1.56
1991	4.65	4.20	0.81	0.03	0.05	0.01						9.75	5.10	0.90	0.09	0.80

[1] Massachusetts sampling strata 25-36.

Appendix 2

ADAPT Run Number 232 1992 12 17 12 28 31
COD: GULF OF MAINE STOCK - GMCOD92: **Includes NEFSC spring and autumn ages 2-6, Mass spring ages 2-4, Mass autumn age 2, and USA Commercial CPUE ages 3-6.**

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 7

For all yrs prior to the terminal year (1991), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age 7: 4 5 6 7
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 8+ is then calculated from the following
ratios of F[age 8+] to F[age 7]

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 8+ group is then calculated
using the following method: CATCHEQ

Partial recruitment estimate for 1991

1	0.0001
2	0.0746
3	0.5211
4	1.0000
5	1.0000
6	1.0000
7	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: NONE

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 2	2.0000000E3	1.0000000E0	1.0000000E6
N 3	3.0000000E3	1.0000000E0	1.0000000E6
N 4	5.0000000E2	1.0000000E0	1.0000000E6
N 5	5.0000000E2	1.0000000E0	1.0000000E6
N 6	5.0000000E2	1.0000000E0	1.0000000E6
qRV SPR 2	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 3	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 4	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 5	1.0000000E-2	0.0000000E0	1.0000000E0
qRV SPR 6	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 2	1.0000000E-2	0.0000000E0	1.0000000E0

qRV FAL 3	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 4	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 5	1.0000000E-2	0.0000000E0	1.0000000E0
qRV FAL 6	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 3	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 4	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 5	1.0000000E-2	0.0000000E0	1.0000000E0
qCM CPE 6	1.0000000E-2	0.0000000E0	1.0000000E0
qMA SPR 2	1.0000000E-2	0.0000000E0	1.0000000E0
qMA SPR 3	1.0000000E-2	0.0000000E0	1.0000000E0
qMA SPR 4	1.0000000E-2	0.0000000E0	1.0000000E0
qMA FAL 2	1.0000000E-2	0.0000000E0	1.0000000E0

The following indices of abundance are available:

1	RV SPR 2
2	RV SPR 3
3	RV SPR 4
4	RV SPR 5
5	RV SPR 6
6	RV FAL 2
7	RV FAL 3
8	RV FAL 4
9	RV FAL 5
10	RV FAL 6
11	CM CPE 2
12	CM CPE 3
13	CM CPE 4
14	CM CPE 5
15	CM CPE 6
16	MA SPR 2
17	MA SPR 3
18	MA SPR 4
19	MA FAL 2
20	MA FAL 3
21	
22	
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 12 13 14 15 16 17 18 19

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

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992*******	
1	1.019	0.978	1.033	0.238	0.330	0.638	1.053	0.649	0.190	0.209	0.250	0.599
2	0.516	0.833	1.147	0.622	0.647	0.486	0.633	0.790	1.327	0.355	0.220	0.689
3	0.694	0.641	0.741	0.665	0.387	0.300	0.355	0.632	0.627	1.477	0.260	0.616
4	0.864	0.357	0.190	0.677	0.074	0.128	0.217	0.090	0.167	0.268	1.310	0.395
5	0.117	0.181	0.053	0.095	0.046	0.011	0.087	0.077	0.032	0.024	0.210	0.085
6	0.619	0.700	1.660	0.384	0.378	0.301	0.599	1.951	0.416	0.029	0.142	0.653
7	0.382	3.142	0.977	0.421	0.910	0.490	1.324	2.245	2.391	0.367	0.142	1.163
8	0.549	2.473	0.852	0.565	0.763	0.654	0.600	0.960	1.356	1.643	0.221	0.967
9	0.474	1.167	0.139	0.399	0.209	0.333	0.257	0.528	0.294	0.623	0.632	0.460
10	0.089	0.248	0.264	0.220	0.218	0.086	0.061	0.110	0.174	0.278	0.079	0.166
12	0.101	0.143	0.069	0.063	0.089	0.020	0.051	0.065	0.134	0.031	-999.000	0.076
13	0.071	0.064	0.083	0.043	0.033	0.037	0.033	0.060	0.081	0.139	-999.000	0.064
14	0.039	0.039	0.024	0.027	0.010	0.009	0.014	0.018	0.017	0.028	-999.000	0.023
15	0.004	0.026	0.011	0.006	0.007	0.002	0.002	0.003	0.006	0.005	-999.000	0.007
16	7.060	18.572	5.408	3.822	3.222	6.997	11.356	25.260	6.890	3.560	-999.000	9.215
17	3.418	5.331	2.271	2.794	0.887	2.268	2.511	6.580	17.770	2.540	-999.000	4.637
18	1.147	0.501	0.865	0.692	0.426	0.257	1.370	0.458	2.640	5.030	-999.000	1.339
19	5.652	2.346	0.651	0.344	0.419	1.150	2.386	20.490	2.700	9.130	4.200	4.497

SUMMARY OF WEIGHTING USED IN THE OBJECTIVE FUNCTION

EXOGENOUS WEIGHTS BY INDEX AND YR (omega)

	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
2	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
4	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
6	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
8	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
10	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	-99.00
13	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	-99.00
15	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	-99.00
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-99.00
19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Negative weights in the above table indicate missing values

DOWNWEIGHTS BY YEAR (delta)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ITERATIVE RE-WEIGHTS BY INDEX (chi)

	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	19
	1.0000

FINAL SS WEIGHTS BY INDEX NUMBER AND YR - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
18	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-99.0000
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Negative weights in the above table indicate missing values

CATCH AT AGE (thousands) - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2	1380.000	866.000	446.000	407.000	84.000	216.000	160.000	337.000	205.000	344.000
3	1633.000	2357.000	1240.000	1445.000	2164.000	595.000	1443.000	1583.000	3425.000	934.000
4	1143.000	1058.000	1500.000	991.000	813.000	1109.000	953.000	1454.000	2064.000	4161.000
5	633.000	638.000	437.000	630.000	250.000	277.000	406.000	449.000	430.000	851.000
6	69.000	422.000	194.000	128.000	177.000	66.000	43.000	81.000	157.000	143.000
7	91.000	47.000	74.000	78.000	39.000	51.000	9.000	35.000	27.000	41.000
8	139.000	108.000	62.000	58.000	56.000	28.000	21.000	21.000	72.000	38.000
1+	5088.001	5496.001	3953.001	3737.001	3583.001	2342.001	3035.001	3960.001	6380.001	6512.001

CAA summary for ages 2 7 3 7 4 7 5 7 6 7

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	4949.000	5388.000	3891.000	3679.000	3527.000	2314.000	3014.000	3939.000	6308.000	6474.000
3	3569.000	4522.000	3445.000	3272.000	3443.000	2098.000	2854.000	3602.000	6103.000	6130.000
4	1936.000	2165.000	2205.000	1827.000	1279.000	1503.000	1411.000	2019.000	2678.000	5196.000
5	793.000	1107.000	705.000	836.000	466.000	394.000	458.000	565.000	614.000	1035.000
6	160.000	469.000	268.000	206.000	216.000	117.000	52.000	116.000	184.000	184.000

WT AT AGE (MID-YR) in kg. - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2	1.156	1.164	1.159	1.260	1.304	1.313	1.268	1.247	1.071	1.130
3	1.664	1.660	1.670	1.746	1.837	1.684	1.881	1.776	1.692	1.568
4	2.764	2.475	2.721	2.840	2.923	3.283	2.426	2.993	2.271	2.512
5	4.770	3.778	3.677	4.466	4.619	4.831	5.166	3.864	4.265	4.136
6	6.739	5.962	5.898	5.525	6.067	6.824	6.767	4.872	7.645	7.309
7	8.944	5.808	8.119	7.901	7.669	8.878	9.932	9.267	10.734	9.642
8	12.864	11.461	12.653	12.270	12.027	12.925	12.190	17.032	14.857	13.399

WT AT AGE (JAN 1) in kg. - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.791	0.793	0.761	0.748	0.745	0.758	0.765	0.825	0.803	0.803	0.779
2	0.965	1.024	1.021	1.065	1.083	1.087	1.068	1.059	0.982	1.008	1.008
3	1.364	1.385	1.394	1.423	1.521	1.482	1.572	1.501	1.453	1.296	1.266
4	2.364	2.029	2.125	2.178	2.259	2.456	2.021	2.373	2.008	2.062	1.897
5	4.267	3.231	3.017	3.486	3.622	3.758	4.118	3.062	3.573	3.065	3.061
6	7.259	5.333	4.720	4.507	5.205	5.614	5.718	5.017	5.435	5.583	5.582
7	7.764	6.256	6.957	6.826	6.509	7.339	8.233	7.919	7.232	8.586	9.568
8	12.864	11.461	12.653	12.270	12.027	12.925	12.190	17.032	14.857	13.399	13.399

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) - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	6	6	6	6	6	6	6	6	6	6
2	50	50	50	50	50	50	50	50	50	50
3	84	84	84	84	84	84	84	84	84	84
4	96	96	96	96	96	96	96	96	96	96
5	100	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100	100	100	100

SEX RATIO (Percent Female) - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	50	50	50	50	50	50	50	50	50	50
2	50	50	50	50	50	50	50	50	50	50
3	50	50	50	50	50	50	50	50	50	50
4	50	50	50	50	50	50	50	50	50	50
5	50	50	50	50	50	50	50	50	50	50
6	50	50	50	50	50	50	50	50	50	50
7	50	50	50	50	50	50	50	50	50	50
8	50	50	50	50	50	50	50	50	50	50

BEGIN MARQUARDT ALGORITHM

LAMBDA 1.00000E-2
RSS 2.23249E3
NPHI 2.23249E3

par

2.00000E3	3.00000E3	5.00000E2	5.00000E2	5.00000E2	1.00000E-2	1.00000E-2	1.00000E-2	1.
00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1
.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2	1.00000E-2		

LAMBDA 1.00000E-1
RSS 1.71440E3
NPHI 1.71440E3

par

2.11794E3	2.78649E3	5.40870E2	5.81565E2	4.72365E2	5.81613E-3	6.16869E-3	6.72779E-3	7.
39413E-3	8.87229E-3	5.57362E-3	5.89781E-3	6.65980E-3	7.63899E-3	9.04348E-3	6.02418E-3	6
.66959E-3	7.79183E-3	8.88864E-3	5.75597E-3	5.84710E-3	6.36166E-3	5.32915E-3		

LAMBDA 1.00000E0
RSS 1.33753E3
NPHI 1.33753E3

par

2.22117E3	2.59829E3	5.77418E2	6.63687E2	4.46509E2	3.72204E-3	4.12513E-3	4.81440E-3	5.
71219E-3	7.99148E-3	3.45649E-3	3.81201E-3	4.72760E-3	6.06197E-3	8.28191E-3	3.95438E-3	4
.73623E-3	6.28133E-3	8.01495E-3	3.65301E-3	3.75289E-3	4.35332E-3	3.19955E-3		

LAMBDA 1.00000E1
RSS 1.08104E3
NPHI 1.08104E3

par

2.24364E3	2.37421E3	5.86203E2	7.16212E2	4.10946E2	2.66794E-3	3.03949E-3	3.72727E-3	4.
68420E-3	7.36912E-3	2.42470E-3	2.74230E-3	3.63867E-3	5.07319E-3	7.73894E-3	2.86815E-3	3
.62878E-3	5.29580E-3	7.37790E-3	2.59463E-3	2.67946E-3	3.24695E-3	2.19585E-3		

LAMBDA 1.00000E2
RSS 9.70750E2
NPHI 9.70750E2

par

2.11711E3	2.12112E3	5.40417E2	6.87441E2	3.67042E2	2.31413E-3	2.65777E-3	3.33216E-3	4.
29540E-3	7.10463E-3	2.08536E-3	2.37490E-3	3.24497E-3	4.69394E-3	7.50845E-3	2.48892E-3	3
.21529E-3	4.88965E-3	7.09625E-3	2.23559E-3	2.31060E-3	2.84506E-3	1.87261E-3		

LAMBDA 1.00000E1
RSS 7.73457E2
NPHI 7.73457E2

par
1.71933E3 1.52483E3 3.97497E2 5.62762E2 2.65815E2 1.76339E-3 2.06216E-3 2.70764E-3 3.
66402E-3 6.61472E-3 1.56288E-3 1.80856E-3 2.62458E-3 4.07052E-3 7.06974E-3 1.91608E-3 2
.57999E-3 4.22997E-3 6.61780E-3 1.68573E-3 1.75726E-3 2.23499E-3 1.38018E-3

LAMBDA 1.00000E2
RSS 6.98977E2
NPHI 6.98977E2

par
1.66432E3 1.40865E3 3.80430E2 5.60184E2 2.49373E2 1.56626E-3 1.84380E-3 2.46364E-3 3.
40145E-3 6.41076E-3 1.37867E-3 1.60446E-3 2.38324E-3 3.80718E-3 6.88869E-3 1.70066E-3 2
.32925E-3 3.95107E-3 6.39901E-3 1.48882E-3 1.55176E-3 1.99945E-3 1.20924E-3

LAMBDA 1.00000E1
RSS 5.69149E2
NPHI 5.69149E2

par
1.44470E3 1.10377E3 3.10750E2 5.05157E2 2.05804E2 1.25666E-3 1.49912E-3 2.07631E-3 2.
97968E-3 6.04686E-3 1.09179E-3 1.28535E-3 2.00103E-3 3.38074E-3 6.55972E-3 1.37007E-3 1
.93857E-3 3.49783E-3 6.03104E-3 1.18305E-3 1.23810E-3 1.63595E-3 9.45205E-4

LAMBDA 1.00000E2
RSS 5.17486E2
NPHI 5.17486E2

par
1.42414E3 1.04583E3 3.05735E2 5.12741E2 1.98769E2 1.13756E-3 1.36473E-3 1.91646E-3 2.
79545E-3 5.88651E-3 9.82779E-4 1.16264E-3 1.84388E-3 3.19169E-3 6.41514E-3 1.23886E-3 1
.77775E-3 3.29999E-3 5.85910E-3 1.06592E-3 1.11486E-3 1.48898E-3 8.46111E-4

LAMBDA 1.00000E1
RSS 4.29220E2
NPHI 4.29220E2

par
1.29616E3 8.73573E2 2.69235E2 4.87306E2 1.76361E2 9.49213E-4 1.15049E-3 1.66190E-3 2.
50077E-3 5.60749E-3 8.11505E-4 9.68490E-4 1.59406E-3 2.88771E-3 6.16059E-3 1.03448E-3 1
.52377E-3 2.97691E-3 5.57064E-3 8.81807E-4 9.23709E-4 1.25864E-3 6.91406E-4

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LAMBDA        1.00000E0
RSS           8.27416E1
NPHI          8.27416E1
par
   1.27966E3      5.79166E2      2.76514E2      6.16694E2      1.46666E2      1.82367E-4     2.73445E-4     5.63955E-4     1.
      16419E-3       4.32543E-3     1.21326E-4     1.82691E-4     5.20073E-4     1.48946E-3     4.98872E-3     1.88651E-4     4
      .42997E-4      1.53237E-3     4.20153E-3     1.38797E-4     1.39154E-4     2.92832E-4     7.44166E-5

LAMBDA        1.00000E-1
RSS           6.20268E1
NPHI          6.20268E1
par
   2.45479E3      1.04757E3      6.21776E2      1.39209E3      2.30062E2      1.61795E-4     2.26393E-4     3.74201E-4     7.
      12951E-4       3.28583E-3     1.26039E-4     1.73538E-4     3.51396E-4     9.08743E-4     3.91661E-3     1.93579E-4     3
      .62210E-4      1.08846E-3     3.33178E-3     1.49145E-4     1.59055E-4     2.68124E-4     9.39852E-5

LAMBDA        1.00000E-2
RSS           5.89238E1
NPHI          5.89238E1
par
   3.43832E3      1.38988E3      1.00496E3      2.20240E3      2.73811E2      1.52234E-4     2.17113E-4     3.77657E-4     7.
      45163E-4       3.26576E-3     1.19618E-4     1.65747E-4     3.52948E-4     9.50921E-4     3.87282E-3     1.87464E-4     3
      .56430E-4      1.10624E-3     3.30846E-3     1.43530E-4     1.57206E-4     2.62261E-4     9.38686E-5

LAMBDA        1.00000E-3
RSS           5.87729E1
NPHI          5.87729E1
par
   3.70108E3      1.47248E3      1.15676E3      2.43511E3      2.71196E2      1.50932E-4     2.15421E-4     3.76111E-4     7.
      47057E-4       3.27057E-3     1.18542E-4     1.64480E-4     3.51484E-4     9.53396E-4     3.87860E-3     1.86102E-4     3
      .55424E-4      1.10639E-3     3.30565E-3     1.42221E-4     1.56009E-4     2.61543E-4     9.29213E-5

LAMBDA        1.00000E-4
RSS           5.87712E1
NPHI          5.87712E1
par
   3.71444E3      1.47843E3      1.17808E3      2.45318E3      2.69940E2      1.50774E-4     2.15206E-4     3.75765E-4     7.
      46969E-4       3.27220E-3     1.18419E-4     1.64316E-4     3.51160E-4     9.53284E-4     3.88054E-3     1.85944E-4     3
      .55371E-4      1.10655E-3     3.30593E-3     1.42075E-4     1.55878E-4     2.61504E-4     9.28264E-5

LAMBDA        1.00000E-5
RSS           5.87712E1
NPHI          5.87712E1
par
   3.71479E3      1.47874E3      1.17976E3      2.45437E3      2.69901E2      1.50759E-4     2.15185E-4     3.75714E-4     7.
      46938E-4       3.27223E-3     1.18407E-4     1.64300E-4     3.51113E-4     9.53243E-4     3.88057E-3     1.85928E-4     3
      .55364E-4      1.10655E-3     3.30591E-3     1.42061E-4     1.55864E-4     2.61499E-4     9.28171E-5
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN 0.00001
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RESULTS

APPROX STATISTICS ASSUMING LINEARITY IN THE NEIGHBORHOOD OF SOLUTION

SUM OF SQUARES	58.771230
ORTHOGONALITY OFFSET.....	0.001472
MEAN SQUARE RESIDUALS	0.349829

PARAMETER	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 2	3.71479E3	1.34253E3	2.76701E0	0.36
N 3	1.47874E3	4.26465E2	3.46742E0	0.29
N 4	1.17976E3	3.47380E2	3.39617E0	0.29
N 5	2.45437E3	8.50396E2	2.88615E0	0.35
N 6	2.69901E2	1.12023E2	2.40933E0	0.42
qRV SPR 2	1.50759E-4	2.78997E-5	5.40362E0	0.19
qRV SPR 3	2.15185E-4	3.92500E-5	5.48242E0	0.18
qRV SPR 4	3.75714E-4	6.83628E-5	5.49589E0	0.18
qRV SPR 5	7.46938E-4	1.36697E-4	5.46419E0	0.18
qRV SPR 6	3.27223E-3	6.08253E-4	5.37971E0	0.19
qRV FAL 2	1.18407E-4	2.19126E-5	5.40362E0	0.19
qRV FAL 3	1.64300E-4	2.99685E-5	5.48242E0	0.18
qRV FAL 4	3.51113E-4	6.38864E-5	5.49589E0	0.18
qRV FAL 5	9.53243E-4	1.74453E-4	5.46419E0	0.18
qRV FAL 6	3.88057E-3	7.21334E-4	5.37971E0	0.19
qCM CPE 3	1.85928E-4	3.51728E-5	5.28612E0	0.19
qCM CPE 4	3.55364E-4	6.70444E-5	5.30043E0	0.19
qCM CPE 5	1.10655E-3	2.08703E-4	5.30204E0	0.19
qCM CPE 6	3.30591E-3	6.23185E-4	5.30487E0	0.19
qMA SPR 2	1.42061E-4	2.70995E-5	5.24221E0	0.19
qMA SPR 3	1.55864E-4	2.94856E-5	5.28612E0	0.19
qMA SPR 4	2.61499E-4	4.93355E-5	5.30043E0	0.19
qMA FAL 2	9.28171E-5	1.71768E-5	5.40362E0	0.19

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 2	7.66624E0	4.05435E0	1.89087E0
N 3		1.06015E1	7.23126E-1
N 4		9.99992E0	7.66630E-1
N 5		2.74726E0	2.79051E0
N 6		8.89130E0	8.62218E-1
qRV SPR 2		4.79181E8	1.59986E-8
qRV SPR 3		2.35204E8	3.25940E-8
qRV SPR 4		7.71530E7	9.93641E-8
qRV SPR 5		1.95209E7	3.92720E-7
qRV SPR 6		1.01714E6	7.53706E-6
qRV FAL 2		7.76801E8	9.86899E-9
qRV FAL 3		4.03453E8	1.90016E-8
qRV FAL 4		8.83436E7	8.67776E-8
qRV FAL 5		1.19856E7	6.39620E-7
qRV FAL 6		7.23229E5	1.06000E-5
qCM CPE 3		2.86409E8	2.67668E-8
qCM CPE 4		7.84020E7	9.77811E-8
qCM CPE 5		8.08596E6	9.48092E-7
qCM CPE 6		9.05925E5	8.46234E-6
qMA SPR 2		4.90596E8	1.56264E-8
qMA SPR 3		4.07551E8	1.88105E-8
qMA SPR 4		1.44788E8	5.29479E-8
qMA FAL 2		1.26419E9	6.06416E-9

Frobenius Norm of J'J is 1783136665
Std Natural Norm of J'J is 1264189242

CATCHABILITY ESTIMATES IN ORIGINAL UNITS

	ESTIMATE	STD. ERR.	C.V.
qRV SPR 2	9.02932E-5	1.67098E-5	0.19
qRV SPR 3	1.48202E-4	2.70323E-5	0.18
qRV SPR 4	2.31562E-4	4.21336E-5	0.18
qRV SPR 5	2.94839E-4	5.39584E-5	0.18
qRV SPR 6	2.77484E-4	5.15798E-5	0.19
qRV FAL 2	7.72806E-5	1.43016E-5	0.19
qRV FAL 3	1.91038E-4	3.48455E-5	0.18
qRV FAL 4	3.39495E-4	6.17725E-5	0.18
qRV FAL 5	4.38034E-4	8.01645E-5	0.18
qRV FAL 6	6.44330E-4	1.19770E-4	0.19
qCM CPE 3	1.42087E-5	2.68792E-6	0.19
qCM CPE 4	2.28696E-5	4.31467E-6	0.19
qCM CPE 5	2.50887E-5	4.73189E-6	0.19
qCM CPE 6	2.35808E-5	4.44513E-6	0.19
qMA SPR 2	1.30905E-3	2.49713E-4	0.19
qMA SPR 3	7.22743E-4	1.36725E-4	0.19
qMA SPR 4	3.50043E-4	6.60405E-5	0.19
qMA FAL 2	4.17407E-4	7.72458E-5	0.19

CORRELATION BETWEEN PARAMETERS ESTIMATED

1.00	0.07	0.05	0.03	0.02	-0.19	-0.02	-0.01	-0.01	-0.01	-0.19	-0.02	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.02	-0.01	-0.00	-0.19
0.07	1.00	0.07	0.05	0.02	-0.14	-0.15	-0.01	-0.01	-0.01	-0.14	-0.15	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.13	-0.01	-0.00	-0.14
0.05	0.07	1.00	0.06	0.03	-0.10	-0.10	-0.15	-0.01	-0.01	-0.10	-0.10	-0.15	-0.01	-0.01	-0.10	-0.01	-0.00	-0.00	-0.10	-0.10	-0.01	-0.10
0.03	0.05	0.06	1.00	0.03	-0.07	-0.07	-0.08	-0.19	-0.04	-0.07	-0.07	-0.08	-0.19	-0.04	-0.06	-0.08	-0.02	-0.04	-0.07	-0.06	-0.08	-0.07
0.02	0.02	0.03	0.03	1.00	-0.03	-0.03	-0.04	-0.08	-0.26	-0.03	-0.03	-0.04	-0.08	-0.26	-0.03	-0.03	-0.08	-0.07	-0.03	-0.03	-0.03	-0.03
-0.19	-0.14	-0.10	-0.07	-0.03	1.00	0.03	0.02	0.01	0.01	0.06	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.03	0.01	0.01	0.06
-0.02	-0.15	-0.10	-0.07	-0.03	0.03	1.00	0.02	0.01	0.01	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.03	0.01	0.01	0.03
-0.01	-0.01	-0.15	-0.08	-0.04	0.02	0.02	1.00	0.02	0.01	0.02	0.02	0.03	0.02	0.01	0.02	0.01	0.00	0.01	0.02	0.02	0.01	0.02
-0.01	-0.01	-0.01	-0.19	-0.08	0.01	0.01	0.02	1.00	0.03	0.01	0.01	0.02	0.04	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01
-0.01	-0.01	-0.01	-0.04	-0.26	0.01	0.01	0.01	0.03	1.00	0.01	0.01	0.01	0.03	0.07	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
-0.19	-0.14	-0.10	-0.07	-0.03	0.06	0.03	0.02	0.01	0.01	1.00	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.03	0.01	0.01	0.06
-0.02	-0.15	-0.10	-0.07	-0.03	0.03	0.03	0.02	0.01	0.01	0.03	1.00	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.03	0.01	0.01	0.03
-0.01	-0.01	-0.15	-0.08	-0.04	0.02	0.02	0.03	0.02	0.01	0.02	0.02	1.00	0.02	0.01	0.02	0.01	0.00	0.01	0.02	0.02	0.01	0.02
-0.01	-0.01	-0.01	-0.19	-0.08	0.01	0.01	0.02	0.04	0.03	0.01	0.01	0.02	1.00	0.03	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01
-0.01	-0.01	-0.01	-0.04	-0.26	0.01	0.01	0.01	0.03	0.07	0.01	0.01	0.01	0.03	1.00	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
-0.01	-0.01	-0.10	-0.06	-0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	1.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01
-0.00	-0.00	-0.01	-0.08	-0.03	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	1.00	0.00	0.01	0.01	0.01	0.01	0.01
-0.00	-0.00	-0.00	-0.02	-0.08	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.01	0.02	0.00	0.00	1.00	0.01	0.00	0.00	0.00	0.00
-0.00	-0.00	-0.00	-0.04	-0.07	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.01	0.01	0.02	0.00	0.01	0.01	1.00	0.00	0.00	0.01	0.00
-0.02	-0.13	-0.10	-0.07	-0.03	0.03	0.03	0.02	0.01	0.01	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	1.00	0.01	0.01	0.03
-0.01	-0.01	-0.10	-0.06	-0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.01	1.00	0.01	0.01
-0.00	-0.00	-0.01	-0.08	-0.03	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.01	1.00	0.01
-0.19	-0.14	-0.10	-0.07	-0.03	0.06	0.03	0.02	0.01	0.01	0.06	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.03	0.01	0.01	1.00

CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)

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N 2          * . . . . . . . . . . . . . . . . . . . . .
N 3          . * . . . . . . . . . . . . . . . . . . . .
N 4          . . * . . . . . . . . . . . . . . . . . . .
N 5          . . . * . . . . . . . . . . . . . . . . . .
N 6          . . . . * . . . . - . . . . - . . . . . . .
qRV SPR 2    . . . . . * . . . . . . . . . . . . . . . .
qRV SPR 3    . . . . . . * . . . . . . . . . . . . . . .
qRV SPR 4    . . . . . . . * . . . . . . . . . . . . . .
qRV SPR 5    . . . . . . . . * . . . . . . . . . . . . .
qRV SPR 6    . . . . - . . . . * . . . . . . . . . . . .
qRV FAL 2    . . . . . . . . . . * . . . . . . . . . . .
qRV FAL 3    . . . . . . . . . . . * . . . . . . . . . .
qRV FAL 4    . . . . . . . . . . . . * . . . . . . . . .
qRV FAL 5    . . . . . . . . . . . . . * . . . . . . . .
qRV FAL 6    . . . . - . . . . . . . . . * . . . . . . .
qCM CPE 3    . . . . . . . . . . . . . . . * . . . . . .
qCM CPE 4    . . . . . . . . . . . . . . . . * . . . . .
qCM CPE 5    . . . . . . . . . . . . . . . . . * . . . .
qCM CPE 6    . . . . . . . . . . . . . . . . . . * . . .
qMA SPR 2    . . . . . . . . . . . . . . . . . . . * . .
qMA SPR 3    . . . . . . . . . . . . . . . . . . . . * .
qMA SPR 4    . . . . . . . . . . . . . . . . . . . . . *
qMA FAL 2    . . . . . . . . . . . . . . . . . . . . . .
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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 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
1982	0.5316	0.3187	1.0000	0.2130	0.3601	9122.486
1983	0.4905	-0.2869	1.0000	0.7774	1.3144	4978.544
1984	0.5448	-0.3634	1.0000	0.9083	1.5356	4611.861
1985	-0.9229	-0.0439	1.0000	-0.8789	-1.4860	6348.078
1986	-0.5960	-0.5212	1.0000	-0.0748	-0.1265	3938.707
1987	0.0632	-0.1058	1.0000	0.1690	0.2858	5966.985
1988	0.5643	0.1912	1.0000	0.3730	0.6307	8030.993
1989	0.0809	0.9008	1.0000	-0.8199	-1.3863	16328.189
1990	-1.1461	-0.7142	1.0000	-0.4318	-0.7301	3247.322
1991	-1.0511	-1.1099	1.0000	0.0587	0.0993	2186.312
1992	-0.8737	-0.5797	1.0000	-0.2939	-0.4969	3714.794

Partial variance for this index is 0.346542

Index 2 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
1982	-0.2880	-0.0641	1.0000	-0.2239	-0.3786	4358.791
1983	0.1902	0.2915	1.0000	-0.1013	-0.1713	6220.184
1984	0.5097	-0.3446	1.0000	0.8543	1.4444	3292.498
1985	-0.1019	-0.3207	1.0000	0.2188	0.3699	3372.315
1986	-0.0625	0.0384	1.0000	-0.1009	-0.1706	4829.098
1987	-0.3486	-0.3893	1.0000	0.0406	0.0687	3148.735
1988	-0.0844	0.0092	1.0000	-0.0935	-0.1581	4689.909
1989	0.1372	0.3248	1.0000	-0.1876	-0.3172	6430.447
1990	0.6560	1.0336	1.0000	-0.3776	-0.6384	13063.460
1991	-0.6635	-0.6307	1.0000	-0.0328	-0.0554	2473.191
1992	-1.1412	-1.1451	1.0000	0.0039	0.0065	1478.737

Partial variance for this index is 0.106721

Index 3 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
1982	0.1185	0.0040	1.0000	0.1145	0.1935	2672.279
1983	0.0395	-0.2412	1.0000	0.2808	0.4747	2091.076
1984	0.1842	0.1062	1.0000	0.0780	0.1318	2959.954
1985	0.0760	-0.5255	1.0000	0.6015	1.0170	1573.671
1986	-0.4653	-0.6049	1.0000	0.1396	0.2360	1453.528
1987	-0.7200	-0.2880	1.0000	-0.4320	-0.7305	1995.663
1988	-0.5517	-0.2662	1.0000	-0.2855	-0.4827	2039.588
1989	0.0251	-0.0491	1.0000	0.0742	0.1255	2534.092
1990	0.0176	0.3646	1.0000	-0.3470	-0.5867	3832.447
1991	0.8742	1.0487	1.0000	-0.1745	-0.2951	7596.389
1992	-0.8631	-0.8136	1.0000	-0.0495	-0.0836	1179.759

Partial variance for this index is 0.09322

Index 4 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
1982	0.7833	0.0985	1.0000	0.6848	1.1578	1477.367
1983	-0.0998	-0.1488	1.0000	0.0490	0.0829	1153.648
1984	-0.7295	-0.5732	1.0000	-0.1563	-0.2643	754.711
1985	0.5395	-0.2277	1.0000	0.7672	1.2971	1066.149
1986	-1.6741	-1.2290	1.0000	-0.4452	-0.7526	391.719
1987	-1.1262	-1.0805	1.0000	-0.0457	-0.0772	454.415
1988	-0.5983	-0.7531	1.0000	0.1548	0.2617	630.446
1989	-1.4777	-0.5055	1.0000	-0.9722	-1.6438	807.563
1990	-0.8621	-0.5674	1.0000	-0.2947	-0.4982	759.106
1991	-0.3879	-0.0526	1.0000	-0.3353	-0.5669	1270.158
1992	1.1996	0.6061	1.0000	0.5935	1.0034	2454.368

Partial variance for this index is 0.288539

Index 5 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
1982	0.3225	-0.5309	1.0000	0.8535	1.4430	179.711
1983	0.7580	0.7342	1.0000	0.0238	0.0402	636.804
1984	-0.4692	0.1837	1.0000	-0.6530	-1.1040	367.241
1985	0.1136	-0.3174	1.0000	0.4310	0.7287	222.491
1986	-0.6117	-0.0091	1.0000	-0.6026	-1.0188	302.842
1987	-2.0424	-1.1737	1.0000	-0.8687	-1.4688	94.503
1988	0.0256	-0.9232	1.0000	0.9488	1.6041	121.404
1989	-0.1013	-0.7197	1.0000	0.6184	1.0455	148.802
1990	-0.9624	-0.1814	1.0000	-0.7810	-1.3205	254.905
1991	-1.2748	-0.2737	1.0000	-1.0011	-1.6926	232.423
1992	0.9068	-0.1242	1.0000	1.0310	1.7432	269.901

Partial variance for this index is 0.660011

Index 6 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
1982	-0.0524	0.0771	1.0000	-0.1296	-0.2191	9122.486
1983	0.0706	-0.5285	1.0000	0.5991	1.0130	4978.544
1984	0.9334	-0.6050	1.0000	1.5384	2.6010	4611.861
1985	-0.5310	-0.2855	1.0000	-0.2456	-0.4152	6348.078
1986	-0.5462	-0.7628	1.0000	0.2166	0.3662	3938.707
1987	-0.7740	-0.3474	1.0000	-0.4266	-0.7212	5966.985
1988	-0.0858	-0.0503	1.0000	-0.0355	-0.0600	8030.993
1989	1.0950	0.6593	1.0000	0.4358	0.7368	16328.189
1990	-0.4515	-0.9558	1.0000	0.5043	0.8526	3247.322
1991	-3.1059	-1.3514	1.0000	-1.7545	-2.9663	2186.312
1992	-1.5238	-0.8213	1.0000	-0.7025	-1.1878	3714.794

Partial variance for this index is 0.725017

Index 7 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
1982	-1.1126	-0.3339	1.0000	-0.7787	-1.3166	4358.791
1983	0.9940	0.0217	1.0000	0.9723	1.6439	6220.184
1984	-0.1745	-0.6144	1.0000	0.4399	0.7438	3292.498
1985	-1.0154	-0.5905	1.0000	-0.4250	-0.7185	3372.315
1986	-0.2451	-0.2314	1.0000	-0.0137	-0.0231	4829.098
1987	-0.8641	-0.6591	1.0000	-0.2051	-0.3467	3148.735
1988	0.1299	-0.2606	1.0000	0.3905	0.6603	4689.909
1989	0.6579	0.0550	1.0000	0.6029	1.0194	6430.447
1990	0.7207	0.7638	1.0000	-0.0430	-0.0727	13063.460
1991	-1.1544	-0.9006	1.0000	-0.2538	-0.4291	2473.191
1992	-2.1013	-1.4149	1.0000	-0.6864	-1.1606	1478.737

Partial variance for this index is 0.310796

Index 8 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
1982	-0.5658	-0.0637	1.0000	-0.5021	-0.8489	2672.279
1983	0.9389	-0.3090	1.0000	1.2479	2.1098	2091.076
1984	-0.1268	0.0385	1.0000	-0.1653	-0.2795	2959.954
1985	-0.5378	-0.5932	1.0000	0.0555	0.0938	1573.671
1986	-0.2368	-0.6727	1.0000	0.4358	0.7368	1453.528
1987	-0.3910	-0.3557	1.0000	-0.0353	-0.0597	1995.663
1988	-0.4772	-0.3339	1.0000	-0.1433	-0.2422	2039.588
1989	-0.0072	-0.1168	1.0000	0.1096	0.1854	2534.092
1990	0.3385	0.2969	1.0000	0.0416	0.0704	3832.447
1991	0.5303	0.9810	1.0000	-0.4507	-0.7621	7596.389
1992	-1.4750	-0.8813	1.0000	-0.5937	-1.0038	1179.759

Partial variance for this index is 0.269569

Index 9 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
1982	0.0315	0.3424	1.0000	-0.3108	-0.5256	1477.367
1983	0.9319	0.0950	1.0000	0.8369	1.4149	1153.648
1984	-1.1969	-0.3293	1.0000	-0.8676	-1.4668	754.711
1985	-0.1403	0.0162	1.0000	-0.1565	-0.2646	1066.149
1986	-0.7878	-0.9851	1.0000	0.1972	0.3335	391.719
1987	-0.3220	-0.8366	1.0000	0.5146	0.8700	454.415
1988	-0.5811	-0.5092	1.0000	-0.0719	-0.1216	630.446
1989	0.1389	-0.2616	1.0000	0.4005	0.6772	807.563
1990	-0.4470	-0.3235	1.0000	-0.1235	-0.2088	759.106
1991	0.3036	0.1913	1.0000	0.1123	0.1899	1270.158
1992	0.3187	0.8500	1.0000	-0.5313	-0.8982	2454.368

Partial variance for this index is 0.242078

Index 10 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
1982	-0.6245	-0.3604	1.0000	-0.2641	-0.4465	179.711
1983	0.4014	0.9047	1.0000	-0.5033	-0.8510	636.804
1984	0.4624	0.3542	1.0000	0.1081	0.1828	367.241
1985	0.2812	-0.1469	1.0000	0.4281	0.7238	222.491
1986	0.2723	0.1614	1.0000	0.1108	0.1874	302.842
1987	-0.6579	-1.0031	1.0000	0.3453	0.5837	94.503
1988	-1.0014	-0.7527	1.0000	-0.2487	-0.4205	121.404
1989	-0.4117	-0.5492	1.0000	0.1374	0.2323	148.802
1990	0.0457	-0.0109	1.0000	0.0566	0.0956	254.905
1991	0.5157	-0.1032	1.0000	0.6189	1.0464	232.423
1992	-0.7428	0.0463	1.0000	-0.7891	-1.3341	269.901

Partial variance for this index is 0.178879

Index 12 CM CPE 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
1982	0.2782	-0.2102	1.0000	0.4884	0.8258	4358.791
1983	0.6263	0.1454	1.0000	0.4809	0.8131	6220.184
1984	-0.1093	-0.4907	1.0000	0.3814	0.6448	3292.498
1985	-0.1935	-0.4668	1.0000	0.2733	0.4621	3372.315
1986	0.1476	-0.1077	1.0000	0.2553	0.4317	4829.098
1987	-1.3516	-0.5354	1.0000	-0.8163	-1.3801	3148.735
1988	-0.4120	-0.1370	1.0000	-0.2750	-0.4650	4689.909
1989	-0.1603	0.1786	1.0000	-0.3389	-0.5730	6430.447
1990	0.5586	0.8874	1.0000	-0.3288	-0.5559	13063.460
1991	-0.8973	-0.7769	1.0000	-0.1204	-0.2035	2473.191

Partial variance for this index is 0.198865

Index 13 CM CPE 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
1982	0.0933	-0.0517	1.0000	0.1450	0.2451	2672.279
1983	-0.0029	-0.2969	1.0000	0.2941	0.4972	2091.076
1984	0.2528	0.0506	1.0000	0.2023	0.3420	2959.954
1985	-0.3988	-0.5812	1.0000	0.1824	0.3084	1573.671
1986	-0.6596	-0.6606	1.0000	0.0010	0.0017	1453.528
1987	-0.5572	-0.3436	1.0000	-0.2135	-0.3610	1995.663
1988	-0.6550	-0.3219	1.0000	-0.3332	-0.5633	2039.588
1989	-0.0734	-0.1048	1.0000	0.0313	0.0530	2534.092
1990	0.2240	0.3089	1.0000	-0.0849	-0.1436	3832.447
1991	0.7686	0.9931	1.0000	-0.2245	-0.3795	7596.389

Partial variance for this index is 0.045498

Index 14 CM CPE 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
1982	0.5456	0.4915	1.0000	0.0541	0.0914	1477.367
1983	0.5346	0.2442	1.0000	0.2904	0.4910	1153.648
1984	0.0628	-0.1802	1.0000	0.2430	0.4108	754.711
1985	0.1915	0.1653	1.0000	0.0262	0.0442	1066.149
1986	-0.7956	-0.8360	1.0000	0.0404	0.0682	391.719
1987	-0.9011	-0.6875	1.0000	-0.2136	-0.3612	454.415
1988	-0.4650	-0.3601	1.0000	-0.1050	-0.1775	630.446
1989	-0.2052	-0.1125	1.0000	-0.0928	-0.1568	807.563
1990	-0.3014	-0.1744	1.0000	-0.1270	-0.2147	759.106
1991	0.2247	0.3404	1.0000	-0.1156	-0.1955	1270.158

Partial variance for this index is 0.027903

Index 15 CM CPE 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
1982	-0.5143	-0.5207	1.0000	0.0064	0.0108	179.711
1983	1.2777	0.7444	1.0000	0.5333	0.9017	636.804
1984	0.4072	0.1940	1.0000	0.2132	0.3605	367.241
1985	-0.2458	-0.3072	1.0000	0.0614	0.1038	222.491
1986	0.0155	0.0012	1.0000	0.0144	0.0243	302.842
1987	-1.1790	-1.1634	1.0000	-0.0156	-0.0264	94.503
1988	-1.5537	-0.9129	1.0000	-0.6408	-1.0834	121.404
1989	-0.7614	-0.7094	1.0000	-0.0519	-0.0878	148.802
1990	-0.1525	-0.1712	1.0000	0.0187	0.0316	254.905
1991	-0.4024	-0.2635	1.0000	-0.1389	-0.2348	232.423

Partial variance for this index is 0.087948

Index 16 MA 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
1982	-0.2664	0.2592	1.0000	-0.5256	-0.8886	9122.486
1983	0.7009	-0.3464	1.0000	1.0472	1.7705	4978.544
1984	-0.5329	-0.4229	1.0000	-0.1101	-0.1861	4611.861
1985	-0.8800	-0.1033	1.0000	-0.7767	-1.3132	6348.078
1986	-1.0508	-0.5806	1.0000	-0.4702	-0.7949	3938.707
1987	-0.2753	-0.1653	1.0000	-0.1101	-0.1861	5966.985
1988	0.2089	0.1318	1.0000	0.0771	0.1304	8030.993
1989	1.0084	0.8414	1.0000	0.1670	0.2824	16328.189
1990	-0.2907	-0.7737	1.0000	0.4829	0.8165	3247.322
1991	-0.9510	-1.1693	1.0000	0.2182	0.3690	2186.312

Partial variance for this index is 0.290766

Index 17 MA 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
1982	-0.3050	-0.3866	1.0000	0.0816	0.1379	4358.791
1983	0.1395	-0.0310	1.0000	0.1704	0.2882	6220.184
1984	-0.7138	-0.6671	1.0000	-0.0467	-0.0790	3292.498
1985	-0.5066	-0.6432	1.0000	0.1366	0.2309	3372.315
1986	-1.6540	-0.2841	1.0000	-1.3699	-2.3161	4829.098
1987	-0.7152	-0.7118	1.0000	-0.0034	-0.0057	3148.735
1988	-0.6134	-0.3134	1.0000	-0.3000	-0.5073	4689.909
1989	0.3500	0.0023	1.0000	0.3477	0.5879	6430.447
1990	1.3434	0.7110	1.0000	0.6324	1.0692	13063.460
1991	-0.6019	-0.9533	1.0000	0.3514	0.5940	2473.191

Partial variance for this index is 0.305813

Index 18 MA 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
1982	-0.1545	-0.3584	1.0000	0.2039	0.3448	2672.279
1983	-0.9828	-0.6036	1.0000	-0.3791	-0.6410	2091.076
1984	-0.4367	-0.2561	1.0000	-0.1805	-0.3052	2959.954
1985	-0.6598	-0.8879	1.0000	0.2281	0.3857	1573.671
1986	-1.1449	-0.9673	1.0000	-0.1776	-0.3003	1453.528
1987	-1.6503	-0.6503	1.0000	-1.0000	-1.6906	1995.663
1988	0.0232	-0.6286	1.0000	0.6518	1.1019	2039.588
1989	-1.0725	-0.4115	1.0000	-0.6610	-1.1176	2534.092
1990	0.6792	0.0022	1.0000	0.6770	1.1446	3832.447
1991	1.3238	0.6863	1.0000	0.6374	1.0777	7596.389

Partial variance for this index is 0.347133

Index 19 MA 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
1982	0.2286	-0.1664	1.0000	0.3950	0.6678	9122.486
1983	-0.6507	-0.7720	1.0000	0.1213	0.2050	4978.544
1984	-1.9327	-0.8485	1.0000	-1.0842	-1.8331	4611.861
1985	-2.5705	-0.5290	1.0000	-2.0416	-3.4517	6348.078
1986	-2.3733	-1.0063	1.0000	-1.3670	-2.3113	3938.707
1987	-1.3637	-0.5909	1.0000	-0.7728	-1.3066	5966.985
1988	-0.6338	-0.2938	1.0000	-0.3400	-0.5748	8030.993
1989	1.5165	0.4158	1.0000	1.1007	1.8610	16328.189
1990	-0.5102	-1.1993	1.0000	0.6891	1.1651	3247.322
1991	0.7081	-1.5949	1.0000	2.3030	3.8938	2186.312
1992	-0.0683	-1.0648	1.0000	0.9965	1.6847	3714.794

Partial variance for this index is 1.653861

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

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992********	
1	0.3601	1.3144	1.5356	-1.4860	-0.1265	0.2858	0.6307	-1.3863	-0.7301	0.0993	-0.4969	0.0000
2	-0.3786	-0.1713	1.4444	0.3699	-0.1706	0.0687	-0.1581	-0.3172	-0.6384	-0.0554	0.0065	0.0000
3	0.1935	0.4747	0.1318	1.0170	0.2360	-0.7305	-0.4827	0.1255	-0.5867	-0.2951	-0.0836	0.0000
4	1.1578	0.0829	-0.2643	1.2971	-0.7526	-0.0772	0.2617	-1.6438	-0.4982	-0.5669	1.0034	-0.0000
5	1.4430	0.0402	-1.1040	0.7287	-1.0188	-1.4688	1.6041	1.0455	-1.3205	-1.6926	1.7432	-0.0000
6	-0.2191	1.0130	2.6010	-0.4152	0.3662	-0.7212	-0.0600	0.7368	0.8526	-2.9663	-1.1878	0.0000
7	-1.3166	1.6439	0.7438	-0.7185	-0.0231	-0.3467	0.6603	1.0194	-0.0727	-0.4291	-1.1606	0.0000
8	-0.8489	2.1098	-0.2795	0.0938	0.7368	-0.0597	-0.2422	0.1854	0.0704	-0.7621	-1.0038	0.0000
9	-0.5256	1.4149	-1.4668	-0.2646	0.3335	0.8700	-0.1216	0.6772	-0.2088	0.1899	-0.8982	-0.0000
10	-0.4465	-0.8510	0.1828	0.7238	0.1874	0.5837	-0.4205	0.2323	0.0956	1.0464	-1.3341	-0.0000
12	0.8258	0.8131	0.6448	0.4621	0.4317	-1.3801	-0.4650	-0.5730	-0.5559	-0.2035	-99.0000	0.0000
13	0.2451	0.4972	0.3420	0.3084	0.0017	-0.3610	-0.5633	0.0530	-0.1436	-0.3795	-99.0000	0.0000
14	0.0914	0.4910	0.4108	0.0442	0.0682	-0.3612	-0.1775	-0.1568	-0.2147	-0.1955	-99.0000	-0.0000
15	0.0108	0.9017	0.3605	0.1038	0.0243	-0.0264	-1.0834	-0.0878	0.0316	-0.2348	-99.0000	-0.0000
16	-0.8886	1.7705	-0.1861	-1.3132	-0.7949	-0.1861	0.1304	0.2824	0.8165	0.3690	-99.0000	0.0000
17	0.1379	0.2882	-0.0790	0.2309	-2.3161	-0.0057	-0.5073	0.5879	1.0692	0.5940	-99.0000	0.0000
18	0.3448	-0.6410	-0.3052	0.3857	-0.3003	-1.6906	1.1019	-1.1176	1.1446	1.0777	-99.0000	0.0000
19	0.6678	0.2050	-1.8331	-3.4517	-2.3113	-1.3066	-0.5748	1.8610	1.1651	3.8938	1.6847	0.0000
**	0.0474	0.6332	0.1600	-0.1047	-0.3016	-0.3841	-0.0260	0.0847	0.0153	-0.0284	-0.1570	0.0000

-99 in the above table indicates a missing value

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

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992*******	
1	0.08	1.03	1.40	1.31	0.01	0.05	0.24	1.14	0.32	0.01	0.15	5.73
2	0.09	0.02	1.24	0.08	0.02	0.00	0.01	0.06	0.24	0.00	0.00	1.77
3	0.02	0.13	0.01	0.62	0.03	0.32	0.14	0.01	0.20	0.05	0.00	1.54
4	0.80	0.00	0.04	1.00	0.34	0.00	0.04	1.61	0.15	0.19	0.60	4.77
5	1.24	0.00	0.73	0.32	0.62	1.28	1.53	0.65	1.04	1.71	1.81	10.92
6	0.03	0.61	4.03	0.10	0.08	0.31	0.00	0.32	0.43	5.24	0.84	11.99
7	1.03	1.61	0.33	0.31	0.00	0.07	0.26	0.62	0.00	0.11	0.80	5.14
8	0.43	2.65	0.05	0.01	0.32	0.00	0.03	0.02	0.00	0.35	0.60	4.46
9	0.16	1.19	1.28	0.04	0.07	0.45	0.01	0.27	0.03	0.02	0.48	4.00
10	0.12	0.43	0.02	0.31	0.02	0.20	0.11	0.03	0.01	0.65	1.06	2.96
12	0.41	0.39	0.25	0.13	0.11	1.13	0.13	0.20	0.18	0.02	-99.00	2.95
13	0.04	0.15	0.07	0.06	0.00	0.08	0.19	0.00	0.01	0.09	-99.00	0.68
14	0.00	0.14	0.10	0.00	0.00	0.08	0.02	0.01	0.03	0.02	-99.00	0.41
15	0.00	0.48	0.08	0.01	0.00	0.00	0.70	0.00	0.00	0.03	-99.00	1.31
16	0.47	1.87	0.02	1.03	0.38	0.02	0.01	0.05	0.40	0.08	-99.00	4.32
17	0.01	0.05	0.00	0.03	3.19	0.00	0.15	0.21	0.68	0.21	-99.00	4.54
18	0.07	0.24	0.06	0.09	0.05	1.70	0.72	0.74	0.78	0.69	-99.00	5.15
19	0.27	0.03	2.00	7.09	3.18	1.02	0.20	2.06	0.81	9.02	1.69	27.36
**	5.26	11.03	11.70	12.53	8.42	6.72	4.49	8.01	5.31	18.50	8.03	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	12
**	0.34654161	0.10672085	0.09322000	0.28853864	0.66001114	0.72501690	0.31079642	0.26956894	0.24207804	0.17887915	0.19886526
**	0.05608233	0.01727110	0.01508620	0.04669546	0.10681246	0.11733262	0.05029753	0.04362551	0.03917654	0.02894879	0.03218322

	13	14	15	16	17	18	19**********	
**	0.04549813	0.02790256	0.08794751	0.29076572	0.30581335	0.34713340	1.65386124	6.17915887
**	0.00736316	0.00451559	0.01423293	0.04705587	0.04949110	0.05617810	0.26765152	1.00000000

STOCK NUMBERS (Jan 1) in thousands - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	6080.809	5632.941	7753.562	4810.749	7288.093	9809.079	19943.296	3966.289	2670.369	4537.261	0.000
2	9122.486	4978.544	4611.861	6348.078	3938.707	5966.985	8030.993	16328.189	3247.322	2186.312	3714.794
3	4358.791	6220.184	3292.498	3372.315	4829.098	3148.735	4689.909	6430.447	13063.460	2473.191	1478.737
4	2672.279	2091.076	2959.954	1573.671	1453.528	1995.663	2039.588	2534.092	3832.447	7596.389	1179.759
5	1477.367	1153.648	754.711	1066.149	391.719	454.415	630.446	807.563	759.106	1270.158	2454.368
6	179.711	636.804	367.241	222.491	302.842	94.503	121.404	148.802	254.905	232.423	269.901
7	210.952	84.701	139.529	125.133	66.341	87.789	17.653	60.489	48.537	66.639	60.900
8	318.271	191.317	115.035	91.152	93.490	47.319	40.567	35.636	127.218	60.531	33.321
1+	24420.665	20989.216	19994.390	17609.739	18363.818	21604.488	35513.857	30311.507	24003.363	18422.903	9191.781

Summaries for ages 2 7 3 7 4 7 5 7 6 7

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
2	18021.586	15164.958	12125.794	12707.837	10982.235	11748.090	15529.993	26309.582	21205.777	13825.112	9158.460
3	8899.100	10186.413	7513.933	6359.759	7043.528	5781.105	7499.000	9981.393	17958.455	11638.799	5443.666
4	4540.310	3966.229	4221.435	2987.444	2214.430	2632.371	2809.091	3550.946	4894.994	9165.609	3964.929
5	1868.031	1875.153	1261.481	1413.773	760.902	636.708	769.503	1016.853	1062.547	1569.220	2785.169
6	390.664	721.505	506.770	347.624	369.182	182.293	139.057	209.291	303.441	299.062	330.801

FISHING MORTALITY - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.1829	0.2135	0.1130	0.0735	0.0239	0.0408	0.0223	0.0231	0.0723	0.1910
3	0.5345	0.5426	0.5382	0.6416	0.6837	0.2343	0.4156	0.3175	0.3421	0.5402
4	0.6400	0.8191	0.8211	1.1906	0.9627	0.9523	0.7265	1.0054	0.9044	0.9298
5	0.6416	0.9447	1.0214	1.0586	1.2219	1.1199	1.2438	0.9531	0.9836	1.3488
6	0.5522	1.3182	0.8766	1.0101	1.0383	1.4777	0.4967	0.9203	1.1416	1.1393
7	0.6477	0.9500	0.8822	1.1676	1.0490	1.0273	0.8288	1.0202	0.9540	1.1393
8	0.6477	0.9500	0.8822	1.1676	1.0490	1.0273	0.8288	1.0202	0.9540	1.1393

Avg F for ages 2 7 3 7 4 7 5 7 6 7

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	0.5332	0.7980	0.7088	0.8570	0.8299	0.8087	0.6223	0.7066	0.7330	0.8814
3	0.6032	0.9149	0.8279	1.0137	0.9911	0.9623	0.7423	0.8433	0.8651	1.0195
4	0.6204	1.0080	0.9004	1.1067	1.0680	1.1443	0.8239	0.9748	0.9959	1.1393
5	0.6138	1.0709	0.9268	1.0788	1.1030	1.2083	0.8564	0.9645	1.0264	1.2092
6	0.6000	1.1341	0.8794	1.0889	1.0436	1.2525	0.6627	0.9702	1.0478	1.1393

Avg F (weighted by N) for ages 2 7 3 7 4 7 5 7 6 7

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	0.3825	0.5381	0.4899	0.4724	0.5152	0.3082	0.2877	0.2256	0.4364	0.7863
3	0.5870	0.6968	0.7211	0.8706	0.7899	0.5841	0.5721	0.5569	0.5022	0.8981
4	0.6374	0.9385	0.8638	1.1291	1.0215	1.0026	0.8333	0.9902	0.9295	0.9947
5	0.6337	1.0718	0.9639	1.0606	1.1337	1.1602	1.1164	0.9523	1.0201	1.3089
6	0.6038	1.2750	0.8782	1.0668	1.0402	1.2608	0.5388	0.9492	1.1116	1.1393

Avg F (wt by catch) for ages 2 7 3 7 4 7 5 7 6 7

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	0.4769	0.6559	0.6762	0.8220	0.7923	0.7193	0.6070	0.6374	0.5836	0.8954
3	0.5905	0.7406	0.7491	0.9151	0.8110	0.7891	0.6397	0.6948	0.6008	0.9349
4	0.6377	0.9562	0.8678	1.1315	1.0265	1.0088	0.8690	0.9907	0.9315	1.0059
5	0.6345	1.0873	0.9670	1.0613	1.1377	1.1678	1.1655	0.9526	1.0227	1.3116
6	0.6065	1.2813	0.8782	1.0697	1.0402	1.2814	0.5541	0.9504	1.1141	1.1393

BACKCALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.28	0.16	0.11	0.06	0.02	0.03	0.02	0.02	0.06	0.14
3	0.83	0.41	0.53	0.54	0.56	0.16	0.33	0.31	0.30	0.40
4	0.99	0.62	0.80	1.00	0.79	0.64	0.58	0.99	0.79	0.69
5	0.99	0.72	1.00	0.89	1.00	0.76	1.00	0.93	0.86	1.00
6	0.85	1.00	0.86	0.85	0.85	1.00	0.40	0.90	1.00	0.84
7	1.00	0.72	0.86	0.98	0.86	0.70	0.67	1.00	0.84	0.84
8	1.00	0.72	0.86	0.98	0.86	0.70	0.67	1.00	0.84	0.84

MEAN BIOMASS (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	4960.186	4594.855	6324.670	3924.184	5944.981	8001.379	16267.978	3235.348	2178.250	3701.096
2	8761.257	4746.314	4589.415	6998.055	4601.812	6962.632	9130.994	18250.076	3044.543	2044.765
3	5137.367	7287.630	3888.246	3980.726	5890.142	4301.187	6587.457	8915.337	17062.348	2739.941
4	4997.003	3245.516	5046.459	2413.844	2511.664	3889.605	3226.066	4407.098	5269.067	11432.745
5	4764.378	2595.555	1602.173	2708.514	965.489	1218.874	1723.335	1851.889	1897.885	2671.069
6	851.177	1952.824	1326.302	712.952	1053.666	312.583	591.695	436.037	1072.816	936.041
7	1272.240	292.331	692.086	538.779	290.523	448.924	109.508	323.796	309.091	354.040
8	2760.785	1302.934	889.242	609.499	642.092	352.268	308.853	350.602	1121.301	446.899
1+	33504.394	26017.960	24358.594	21886.553	21900.369	25487.451	37945.885	37770.182	31955.301	24326.594

Summaries for ages 2 7 3 7 4 7 5 7 6 7

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	25783.423	20120.171	17144.682	17352.871	15313.296	17133.804	21369.054	34184.233	28655.750	20178.599
3	17022.165	15373.857	12555.267	10354.815	10711.484	10171.173	12238.060	15934.157	25611.207	18133.835
4	11884.798	8086.227	8667.020	6374.089	4821.342	5869.986	5650.603	7018.820	8548.859	15393.894
5	6887.795	4840.711	3620.561	3960.245	2309.678	1980.381	2424.537	2611.722	3279.791	3961.149
6	2123.417	2245.155	2018.388	1251.731	1344.189	761.507	701.203	759.833	1381.907	1290.081

CATCH BIOMASS (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2	1602.809	1013.295	518.751	514.304	109.762	284.274	203.294	421.102	220.186	390.607
3	2746.003	3954.456	2092.792	2554.057	4026.992	1007.566	2737.600	2830.981	5837.816	1480.113
4	3198.096	2658.402	4143.751	2873.975	2418.074	3704.087	2343.678	4431.115	4765.145	10630.206
5	3056.611	2451.935	1636.537	2867.229	1179.743	1365.004	2143.508	1765.094	1866.724	3602.850
6	470.036	2574.185	1162.692	720.138	1093.988	461.906	293.871	401.283	1224.729	1066.453
7	824.014	277.707	610.564	629.092	304.748	461.186	90.763	330.331	294.860	403.365
8	1788.125	1237.753	784.496	711.666	673.532	361.890	255.984	357.678	1069.674	509.162
1+	13685.696	14167.734	10949.584	10870.462	9806.840	7645.914	8068.699	10537.585	15279.136	18082.757

Summaries for ages 2 7 3 7 4 7 5 7 6 7

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	11897.570	12929.980	10165.087	10158.795	9133.307	7284.023	7812.714	10179.906	14209.461	17573.594
3	10294.761	11916.685	9646.336	9644.491	9023.545	6999.749	7609.420	9758.805	13989.275	17182.987
4	7548.758	7962.229	7553.544	7090.434	4996.552	5992.183	4871.821	6927.824	8151.459	15702.874
5	4350.662	5303.827	3409.793	4216.459	2578.479	2288.096	2528.142	2496.709	3386.313	5072.668
6	1294.050	2851.892	1773.256	1349.230	1398.736	923.092	384.634	731.615	1519.589	1469.818

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

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	279.268	259.256	342.256	208.742	315.150	431.623	884.910	189.900	124.471	211.490
2	4128.022	2378.125	2235.356	3229.377	2055.311	3115.612	4133.605	8333.216	1523.338	1032.841
3	4419.886	6395.164	3409.523	3502.206	5326.099	3645.748	5587.333	7435.895	14562.007	2379.669
4	5272.487	3437.366	5093.878	2609.312	2596.884	3882.623	3391.217	4721.398	6146.460	12453.578
5	5478.277	3080.370	1857.316	3013.166	1119.350	1370.345	2040.952	2040.127	2226.525	3006.943
6	1150.792	2636.628	1448.734	819.632	1282.375	401.124	618.035	619.344	1107.789	1038.018
7	1421.929	437.469	810.522	680.069	350.667	525.090	122.428	390.847	289.574	457.653
8	3554.754	1810.129	1215.290	890.438	913.095	498.430	416.568	495.246	1559.278	648.767
1+	25705.416	20434.507	16412.875	14952.941	13958.932	13870.594	17195.049	24225.974	27539.442	21228.961

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 (thousands) - GMCOD92

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	5511.318	5105.394	7027.411	4360.204	6605.535	8890.421	18075.531	3594.831	2420.278	4112.329
2	7578.942	4077.589	3959.806	5554.012	3528.997	5302.842	7201.099	14635.185	2842.711	1809.526
3	3087.360	4390.138	2328.291	2279.912	3206.392	2554.149	3502.104	5019.897	10084.130	1747.411
4	1807.888	1311.320	1854.634	849.945	859.276	1184.771	1329.788	1472.468	2320.153	4551.252
5	998.821	687.018	435.728	606.474	209.026	252.303	333.592	479.267	444.991	645.810
6	126.306	327.545	224.873	129.041	173.672	45.806	87.438	89.499	140.329	128.067
7	142.245	50.333	85.243	68.191	37.883	50.566	11.026	34.941	28.795	36.718
8	214.610	113.687	70.278	49.673	53.386	27.256	25.337	20.585	75.475	33.353
1+	19467.491	16063.025	15986.265	13897.453	14674.166	18308.114	30565.915	25346.673	18356.862	13064.466

Time stamp at end of run 1992 12 17 12 37 59