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E. Cape Cod – Gulf of Maine Yellowtail Flounder

by

Chris Legault, Steve Cadrin, Jeremy King, and Sally Sherman

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E. Cape Cod-Gulf of Maine Yellowtail Flounder

1.0 Background

The Cape Cod-Gulf of Maine yellowtail flounder stock was most recently assessed in 2005 (Cadrin et al. 2005). The stock exhibited high fishing mortality rates and low abundance. The stock was overfished and overfishing was occurring. This report updates the 1994-2006 US catch to reflect the Groundfish Assessment Review Meeting (GARM) Data Meeting recommendations (GARM 2007), provides an updated virtual population analysis as well as a preliminary alternative stock assessment using a forward projecting statistical catch-at-age model, and provides a range of biological reference points for this stock.

2.0 Assessment Data

<u>2.1 Landings</u>
Landings of yellowtail flounder from the Cape Cod-Gulf of Maine stock during 1994-2006 were derived from the new trip-based allocation described in the GARM data meeting (GARM 2007, Table E1, Figure E1). Changes to previous estimates were minimal and uncertainty in the landings due to the random component of the allocation was insignificant (Legault et al. 2008). Landings at age and mean weight at age are determined by port sampling of small, medium, large, and unclassified market categories and pooled age-length keys by half year. Sampling intensity has increased in recent years (Table E2) resulting in lower variability in landings at age estimates (Table E3).

<u>2.2 Discards</u>
Discarded catch for years 1994-2006 was estimated using the Standardized Bycatch Reporting Methodolgy recommended in the GARM data meeting (GARM 2007). Observed ratios of discards of yellowtail flounder to kept of all species for large mesh otter trawl, small mesh otter trawl, scallop dredge, and gillnet were applied to the total landings by these gears by half-year. Uncertainty in the discard estimates was estimated based on the SBRM approach detailed in the GARM data meeting (GARM 2007, Table E4). Discards were approximately 15% of the catch in years 1994-2006 (Table E1; Figure E1). Discards at age and associated mean weights at age were estimated from sea sampled lengths and pooled observer and survey age-length keys

<u>2.3 Total Catch at Age</u>
Total catch at age was formed by adding the landings and discards (Table E5). Average weight at age was computed as the catch weighted average of the weights at age from these two sources (Table E6).

<u>2.4 Survey Indices</u>
Survey abundance and biomass indices are reported in Table E7. Estimates are from valid tows in the Cape Cod-Gulf of Maine area [offshore strata 25-27, 39, 40 (stratum 27 excluded from the fall series); inshore strata 56-66; Massachusetts strata 17-36] standardized according to net, vessel, and door changes. Two new series were included in

this assessment from the Maine-New Hampshire inshore survey. Survey data do not show any strong trends overall (Figure E2).

3.0 Assessment Results

The previous VPA formulation for the Cape Cod-Gulf of Maine yellowtail flounder stock had the plus group set at age 5 (Cadrin and King 2003, Cadrin et al. 2005). Examination of this formulation and a formulation with the plus group set at age 6 with the new catch data found that the 5+ results had a moderate retrospective pattern but a slightly lower mean square residual than the 6+ results. The age 6+ formulation did not exhibit a retrospective pattern (Figure E3). Due to the lack of a retrospective pattern and for consistency with the other yellowtail flounder stocks, the age 6+ VPA formulation was adopted as the new standard VPA for this stock.

Due to the low number of length and age samples available for this stock in some years, a statistical catch at age model (ASAP) was also used to assess this stock. This ASAP assessment is preliminary, but provides an alternative perspective on the stock which does not assume catch at age is known exactly. The ASAP formulation was kept simple for this assessment, using only the same time period of data as the VPA (1985-2006), one fleet, only two time blocks for selectivity (1985-1994 and 1995-2006), steepness of the internal Beverton-Holt stock recruitment function fixed at 1.0 (meaning recruitment deviations are from a constant value independent of stock size), survey tuning indices "East Coast" style (age specific indices of abundance), and input effective sample size for catch in years 1985-1994 set to 50 and set to the number of lengths divided by 50 for years 1994-2006. No attempt to "tune" the model was made and resulting estimates indicate the input survey CVs of 0.4 are too tight relative to the fit model. However, the ASAP assessment does perform sufficiently well for the purpose of estimating biological reference points, with no retrospective pattern (Figure E4). The stock recruitment plots for the two models were similar overall, but values for specific years differed numerically (Figure E5).

Hindcast recruitment estimates were derived for both models by regressing the estimated numbers of recruits from the stock assessments on the NEFSC Fall survey index at age 1 (Figures E6-E7). Combining the hindcast and stock assessment recruitments produced geometric means for the two models for the highest 15 values of 10.6 (VPA) and 10.9 (ASAP) million fish. These values are within the range of recruitment estimates in the respective stock assessments and are reasonable given the catch history of this stock (Table E1; Figure E1).

4.0 Biological Reference Points

4.1 Current Biological Reference Points

Proxies for biological reference points were derived from yield and SSB per recruit analyses and the assumption of constant recruitment (Cadrin and King 2003). Long-term average recruitment was estimated to be 10.5 million at age-1.

MSY = 2,300 mt
SSBmsy = 12,600 mt.
Fmsy = 0.17 fully recruited (derived from F40%)

4.2 Updated Biological Reference Points

Both parametric and empirical approaches to estimating biological reference points were utilized for the VPA and ASAP models.

The parametric approach assumed: a Beverton and Holt stock recruitment relationship; average of the most recent five years for fishery selectivity, maturity (assumed constant over all years), and weight at age; natural mortality of 0.2 for all ages; and either no prior for unfished recruitment or else a prior on unfished recruitment from the top 15 years including hindcast estimates. The program SRFIT (NOAA Fisheries Toolbox) was used to fit the B-H curve and estimate Fmsy. The stock recruitment relationship and biological and fishery characteristics were then entered in AgePro (NOAA Fisheries Toolbox) for stochastic projections of 50 years of fishing at Fmsy, with median values for spawning stock biomass and yield assumed to be the SSBmsy and MSY values (see Legault 2008). The models, VPA and ASAP, produced quite similar results (Table E8). However, both models had an estimated steepness in the B-H curve of 1.0 when no prior on unfished recruitment was used, leading to very high estimates of Fmsy (=Fmax). The use of the prior on unfished recruitment allowed steepness to be estimated, although it was still high (0.949 VPA and 0.954 ASAP), causing Fmsy to remain high. The use of the prior on unfished recruitment did increase SSBmsy and MSY, as expected.

The empirical approach assumed: F40%SPR (the fishing mortality rate that reduces spawning stock biomass per recruit to 40% of the unfished level in equilibrium) is an appropriate proxy for Fmsy; the same biological and fishery characteristics as the parametric case (see above); and two different series of recruitment. The two series were formed from 1) the stock assessment estimates for years 1985-2006 and 2) the top 15 values when the stock assessment series and the hindcast values were combined (15 was an arbitrary selection to include both “typical” high values and very high values). The program AgePro (NOAA Fisheries Toolbox) was used to estimate SSBmsy and MSY proxies using the cumulative distribution option for input recruitment. The F40%SPR values were nearly identical for the VPA and ASAP models, while the SSBmsy and MSY proxies increased by approximately 40% with the higher recruitment (Table E9).

Although the range of values for the Fmsy and SSBmsy reference points was quite high from the eight cases, the F and SSB status determination did not change (Figure E8). As noted above, the parametric Fmsy values were either the same as Fmax (no priors) or else close to Fmax due to the high steepness estimated in the stock recruitment curves. However, even these high F reference points are below the current estimates of F.

The parametric Fmsy values are more than double the associated F40%SPR values used in the empirical approach, due to the high steepness associated with the stock recruitment curves. However, in the empirical approach, the recruitment series are either low relative to hindcast values (1985-2006), or else employ an arbitrary cut-off for the predicted recruitment distribution under Fmsy conditions (top 15). One way to balance the two approaches is to use a stock recruitment relationship to define future recruitment, but base Fmsy on F40%SPR instead of the calculated Fmsy value (Table E10).

Given the similarities in reference points from the two stock assessment models and the strong dependence on unfished recruitment priors, the ranges for biological reference points recommended for Cape Cod-Gulf of Maine yellowtail flounder are

Model	R prior	Fmsy	SSBmsy	MSY
VPA	10.6	0.238	11.12	2.43
VPA	10.6	0.530	5.83	2.70

5.0 References

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Table E.1 Landings, discards, total catch (metric tons), and proportion of total catch which is discards for Cape Cod-Gulf of Maine yellowtail flounder.

year	landings	discards	total catch	%discard
1935	400	100	500	20%
1936	400	100	500	20%
1937	500	200	700	29%
1938	500	200	700	29%
1939	600	200	800	25%
1940	900	300	1200	25%
1941	1300	400	1700	24%
1942	1512	500	2012	25%
1943	1334	400	1734	23%
1944	1531	500	2031	25%
1945	1214	400	1614	25%
1946	1214	400	1614	25%
1947	1122	300	1422	21%
1948	710	200	910	22%
1949	1221	400	1621	25%
1950	1387	400	1787	22%
1951	862	200	1062	19%
1952	837	200	1037	19%
1953	840	200	1040	19%
1954	1114	300	1414	21%
1955	1320	400	1720	23%
1956	1426	400	1826	22%
1957	2426	700	3126	22%
1958	1639	500	2139	23%
1959	1564	500	2064	24%
1960	1539	500	2039	25%
1961	1822	600	2422	25%
1962	1900	600	2500	24%
1963	3600	1000	4600	22%
1964	1857	600	2457	24%
1965	1506	500	2006	25%
1966	1835	300	2135	14%
1967	1591	800	2391	33%
1968	1581	600	2181	28%
1969	1422	300	1722	17%
1970	1310	400	1710	23%
1971	1718	700	2418	29%
1972	1521	300	1821	16%
1973	1724	0	1724	0%
1974	2158	200	2358	8%
1975	2220	0	2220	0%
1976	3845	100	3945	3%
1977	3722	0	3722	0%
1978	4071	400	4471	9%
1979	4439	500	4939	10%
1980	5567	600	6167	10%
1981	3574	600	4174	14%
1982	3635	400	4035	10%
1983	2209	300	2509	12%
1984	1365	20	1385	1%
1985	1171	154	1326	12%
1986	1205	367	1572	23%
1987	1353	271	1624	17%
1988	1275	355	1630	22%
1989	1117	437	1555	28%
1990	3222	1239	4461	28%
1991	1737	515	2251	23%
1992	1031	715	1746	41%
1993	786	145	932	16%
1994	1143	208	1352	15%
1995	1368	147	1515	10%
1996	1176	336	1512	22%
1997	1134	552	1686	33%
1998	1310	311	1621	19%
1999	1303	149	1452	10%
2000	2439	148	2587	6%
2001	2381	239	2620	9%
2002	2057	100	2157	5%
2003	1834	136	1970	7%
2004	913	273	1186	23%
2005	715	282	997	28%
2006	534	85	620	14%

Table E.2 Cape Cod-Gulf of Maine landings (metric tons) and number of lengths available from port samples by half year and market category along with number of ages available for age-length key and number of lengths sampled per 100 metric tons.

		Landings (metric tons)					Number of Lengths					Number	Lengths /
Year	half	unclass	large	small	medium	Total	unclass	large	small	medium	Total	of Ages	100 mt
1994	1	77	191	201	8	476		170	261		431		
	2	24	351	285	6	667		144	106		250		
	Total	101	543	486	14	1143		314	367		681	175	60
1995	1	88	325	346	6	765		491	276		767		
	2	18	321	254	9	603		264	407		671		
	Total	106	646	600	15	1368		755	683		1438	327	105
1996	1	55	270	373	17	714		87			87		
	2	18	233	205	5	462	118	640	495		1253		
	Total	73	503	578	22	1176	118	727	495		1340	367	114
1997	1	46	221	312	11	590		633	388		1021		
	2	20	338	177	10	544		869	996		1865		
	Total	66	558	489	21	1134		1502	1384		2886	703	254
1998	1	194	246	333	22	795		67	281		348		
	2	50	230	232	3	515			619		619		
	Total	244	476	566	25	1310		67	900		967	259	74
1999	1	176	160	222	24	582		150			150		
	2	90	340	284	7	720		268	116		384		
	Total	267	499	506	31	1303		418	116		534	78	41
2000	1	343	442	522	50	1357	464	642	2831	231	4168		
	2	109	471	485	17	1082	102	916	1155		2173		
	Total	452	913	1007	66	2439	566	1558	3986	231	6341	1423	260
2001	1	315	380	382	27	1104	105	218	344		667		
	2	159	611	491	18	1278	534	727	774		2035		
	Total	474	990	873	44	2381	639	945	1118		2702	630	113
2002	1	181	322	187	21	711	304	496	764		1564		
	2	173	596	542	35	1346	225	1098	1646	101	3070		
	Total	354	918	729	56	2057	529	1594	2410	101	4634	1131	225
2003	1	349	264	283	15	910	565	416	1188	133	2302		
	2	234	390	280	19	923	421	1572	1424	574	3991		
	Total	583	654	562	35	1834	986	1988	2612	707	6293	1479	343
2004	1	168	160	143	30	501	263	574	778	679	2294		
	2	73	151	176	12	412	162	267	349	120	898		
	Total	241	311	320	42	913	425	841	1127	799	3192	794	350
2005	1	102	169	116	0	388	2007	186	540		2733		
	2	88	146	92	2	327	667	409	618		1694		
	Total	190	314	208	2	715	2674	595	1158		4427	858	619
2006	1	63	150	96	1	310	214	187	581		982		
	2	57	105	62	0	225	93	1257	1883		3233		
	Total	119	255	158	1	534	307	1444	2464		4215	1029	789
Grand Total		3270	7582	7082	374	18308	6244	12748	18820	1838	39650	9253	217

Table E.3 Cape Cod-Gulf of Maine yellowtail flounder coefficient of variation for landings at age by year.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1994		46%	11%	17%	33%	22%
1995		53%	18%	15%	31%	51%
1996		32%	7%	18%	51%	76%
1997		15%	10%	14%	30%	47%
1998		54%	6%	21%	33%	
1999		53%	13%	22%	111%	128%
2000		13%	5%	7%	27%	41%
2001		19%	5%	17%	30%	48%
2002	73%	13%	6%	11%	26%	55%
2003		16%	6%	8%	21%	30%
2004		28%	8%	8%	19%	28%
2005		20%	6%	8%	18%	32%
2006		15%	9%	9%	35%	25%

Table E.4 Cape Cod-Gulf of Maine yellowtail flounder discards (metric tons) and coefficient of variation by gear and year.

	Otter Trawl Large Mesh		Otter Trawl Small Mesh		Scallop Dredge		Gillnet	
Year	D (mt)	CV	D (mt)	CV	D (mt)	CV	D (mt)	CV
1994	3	58%	13	0%	163	15%	30	141%
1995	32	91%	7	47%	32	11%	76	56%
1996	121	98%	2	51%	148	40%	64	70%
1997	27	35%	9	3%	354	29%	162	47%
1998	33	67%	3	0%	228	9%	48	51%
1999	91	36%	0	27%	27	19%	31	43%
2000	53	48%	2	44%	27	12%	67	58%
2001	127	30%	1	43%	98	7%	13	41%
2002	70	20%	6	53%	13	10%	11	40%
2003	88	28%	1	95%	24	7%	22	58%
2004	220	28%	5	47%	17	3%	32	17%
2005	225	24%	1	36%	4	43%	51	56%
2006	68	29%	3	21%	4	18%	9	89%

Table E.5 Cape Cod-Gulf of Maine yellowtail flounder catch at age (thousands of fish).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	686	1245	907	635	329	121
1986	95	4225	785	304	40	8
1987	19	1885	2331	309	116	53
1988	452	2582	1503	744	199	41
1989	118	2297	1812	298	38	9
1990	84	2897	9400	493	35	28
1991	465	1372	1765	1953	298	74
1992	1709	3979	1961	731	191	14
1993	159	425	1074	795	111	54
1994	19	817	1697	716	210	109
1995	37	526	1777	1188	178	170
1996	26	787	2428	645	104	9
1997	8	1480	2007	847	180	20
1998	38	495	2512	650	152	3
1999	9	743	2292	397	32	7
2000	2	1114	2981	1408	133	35
2001	20	1342	3721	849	145	24
2002	58	1204	2449	905	109	34
2003	10	859	2122	1200	152	70
2004	13	475	1594	571	243	75
2005	15	494	1262	585	82	48
2006	7	189	662	390	84	54

Table E.6 Cape Cod-Gulf of Maine yellowtail flounder catch weight at age (kg).

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	0.132	0.266	0.357	0.489	0.600	0.786
1986	0.103	0.250	0.428	0.534	0.730	0.996
1987	0.056	0.232	0.393	0.548	0.652	0.916
1988	0.123	0.206	0.338	0.523	0.696	0.841
1989	0.129	0.270	0.383	0.650	0.928	1.317
1990	0.079	0.254	0.370	0.550	0.824	0.970
1991	0.124	0.236	0.342	0.517	0.737	1.021
1992	0.053	0.135	0.325	0.498	0.602	1.169
1993	0.089	0.160	0.358	0.418	0.737	0.999
1994	0.089	0.174	0.354	0.512	0.674	0.904
1995	0.055	0.307	0.340	0.422	0.643	0.790
1996	0.109	0.266	0.383	0.462	0.609	1.266
1997	0.145	0.278	0.369	0.478	0.615	0.865
1998	0.079	0.209	0.393	0.609	0.856	0.707
1999	0.148	0.344	0.406	0.604	0.601	0.801
2000	0.101	0.349	0.432	0.566	0.623	0.835
2001	0.226	0.344	0.412	0.573	0.765	0.898
2002	0.218	0.362	0.440	0.565	0.774	1.042
2003	0.087	0.322	0.415	0.535	0.672	0.945
2004	0.077	0.251	0.372	0.460	0.609	0.831
2005	0.062	0.261	0.369	0.514	0.694	0.921
2006	0.106	0.305	0.392	0.478	0.781	0.926

Table E.7a NEFSC Spring survey indices of abundance for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	kg/tow
1985	0.047	0.806	0.865	0.209	0.129	0.033	0.615
1986	0.016	1.794	0.198	0.137	0.100	0.000	0.470
1987	0.053	1.359	2.004	0.541	0.459	1.262	2.527
1988	0.896	3.781	0.922	0.513	0.268	0.154	1.077
1989	0.151	1.852	1.226	0.316	0.330	0.000	0.733
1990	0.000	1.885	5.247	0.212	0.000	0.085	1.656
1991	0.354	3.025	2.450	0.848	0.192	0.040	1.516
1992	0.155	0.915	1.835	0.498	0.018	0.000	0.765
1993	0.064	0.656	1.045	0.563	0.000	0.000	0.501
1994	0.295	2.236	1.341	0.804	0.513	0.173	1.020
1995	0.182	1.040	3.978	3.015	0.408	0.048	2.036
1996	0.015	0.547	1.430	2.009	0.335	0.000	1.108
1997	0.021	0.934	2.025	1.545	0.288	0.000	1.311
1998	0.000	0.725	2.942	0.901	0.144	0.000	1.155
1999	0.018	0.848	3.633	1.853	0.332	0.147	1.977
2000	0.070	9.632	16.992	2.362	0.167	0.083	9.506
2001	0.000	1.201	4.878	1.030	0.216	0.000	2.287
2002	0.015	1.563	7.071	3.262	0.213	0.052	3.693
2003	0.094	0.863	2.405	1.758	0.787	0.025	1.911
2004	0.367	0.597	2.617	0.359	0.140	0.000	1.075
2005	0.089	0.582	3.820	1.284	0.000	0.000	1.415
2006	0.135	1.113	3.419	1.207	0.095	0.034	1.269
2007	0.050	2.168	6.244	4.272	0.214	0.000	3.457

Table E.7b NEFSC Fall survey indices of abundance for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+	kg/tow
1985	4.607	1.767	1.502	0.000	0.000	0.000	1.561
1986	1.239	3.445	0.303	0.000	0.000	0.000	0.907
1987	0.564	1.357	0.500	0.045	0.037	0.000	0.556
1988	3.128	4.587	0.443	0.134	0.000	0.000	1.126
1989	1.474	4.379	1.894	0.260	0.180	0.000	1.871
1990	2.975	5.271	2.443	0.039	0.008	0.000	1.993
1991	1.564	1.396	1.393	0.282	0.000	0.000	1.022
1992	2.519	2.758	1.878	0.948	0.183	0.142	1.932
1993	3.779	3.831	0.510	0.084	0.000	0.000	0.940
1994	2.472	7.368	2.596	0.824	0.354	0.000	2.701
1995	0.558	0.678	1.075	0.283	0.171	0.000	0.783
1996	1.058	2.907	4.928	1.179	0.133	0.000	2.614
1997	1.049	2.486	2.955	1.253	0.583	0.115	2.277
1998	1.022	2.984	1.197	0.986	0.234	0.000	1.637
1999	4.116	8.090	5.526	1.691	0.709	0.027	5.983
2000	0.895	6.789	4.487	0.229	0.000	0.000	3.472
2001	0.135	3.817	2.269	0.095	0.000	0.000	1.891
2002	0.399	1.424	0.561	0.152	0.019	0.000	0.708
2003	0.597	8.775	1.846	0.434	0.253	0.000	3.444
2004	0.237	1.154	0.628	0.024	0.000	0.000	0.491
2005	1.659	1.322	0.543	0.066	0.000	0.000	0.622
2006	2.426	1.515	0.851	0.068	0.000	0.000	0.806
2007	0.373	6.514	4.786	1.526	0.125	0.000	3.451

Table E.7c MADMF Spring survey indices of abundance for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	1.812	7.674	6.959	1.502	0.438	0.336
1986	1.830	15.784	1.692	0.250	0.070	0.056
1987	2.483	4.649	4.909	0.974	0.253	0.148
1988	2.967	12.716	2.425	0.670	0.000	0.041
1989	0.742	18.057	3.320	0.919	0.044	0.000
1990	0.948	10.034	14.971	0.644	0.138	0.033
1991	0.057	4.416	2.998	1.858	0.408	0.134
1992	1.178	8.038	7.702	2.040	1.311	0.076
1993	0.686	5.925	5.429	1.806	0.227	0.291
1994	2.215	19.095	6.343	1.303	0.299	0.097
1995	6.048	10.214	18.383	2.318	0.926	0.021
1996	1.058	11.779	10.057	5.173	1.435	0.053
1997	0.485	10.896	7.592	2.640	0.318	0.000
1998	0.575	3.066	8.638	0.834	0.141	0.016
1999	0.237	4.705	7.781	0.874	0.065	0.000
2000	0.578	13.730	21.107	7.077	0.871	0.302
2001	0.117	6.129	22.987	6.341	1.022	0.000
2002	0.422	1.080	11.798	4.538	0.213	0.148
2003	0.046	6.830	6.548	7.211	1.100	0.043
2004	0.154	2.217	7.247	3.567	0.453	0.019
2005	0.336	5.606	14.139	3.712	0.069	0.023
2006	0.610	6.011	18.593	4.996	0.221	0.092
2007	0.464	11.802	17.292	6.312	0.666	0.000

Table E.7d MADMF Fall survey indices of abundance for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
1985	5.703	1.632	1.031	0.000	0.000	0.018
1986	2.597	4.948	0.203	0.033	0.007	0.000
1987	5.855	2.295	0.493	0.071	0.020	0.000
1988	8.959	11.241	2.270	0.151	0.000	0.000
1989	2.637	5.218	0.960	0.103	0.000	0.000
1990	5.196	11.935	4.841	0.006	0.000	0.000
1991	3.759	5.139	5.028	0.857	0.000	0.000
1992	7.177	3.622	2.076	0.472	0.203	0.000
1993	8.392	7.287	5.802	1.433	0.000	0.000
1994	2.050	8.660	1.273	0.132	0.000	0.000
1995	8.590	12.704	4.504	0.000	0.000	0.000
1996	1.707	2.973	1.690	0.120	0.000	0.000
1997	1.002	5.141	0.624	0.079	0.046	0.000
1998	5.898	5.246	1.692	0.000	0.000	0.000
1999	4.728	9.734	3.086	0.491	0.060	0.000
2000	1.156	6.654	2.948	0.205	0.087	0.031
2001	0.687	5.973	3.167	0.108	0.000	0.000
2002	1.558	0.652	2.284	0.914	0.036	0.000
2003	0.551	5.878	3.123	2.391	0.058	0.000
2004	2.327	8.683	6.357	1.905	0.009	0.000
2005	0.883	4.247	3.817	0.205	0.000	0.000
2006	1.251	4.996	3.808	0.408	0.000	0.000

Table E.7e MENH Spring survey indices of abundance for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
2001	0.000	0.599	2.087	0.535	0.132	0.000
2002	0.000	0.226	1.981	0.845	0.048	0.041
2003	0.000	0.473	0.805	0.850	0.114	0.000
2004	0.000	0.151	1.241	0.492	0.039	0.000
2005	0.021	0.287	1.107	0.280	0.003	0.000
2006	0.000	0.148	0.560	0.152	0.014	0.003
2007	0.000	0.859	2.661	1.071	0.129	0.000

Table E.7f MENH Fall survey indices of abundance for Cape Cod-Gulf of Maine yellowtail flounder.

Year	age 1	age 2	age 3	age 4	age 5	age 6+
2000	0.053	1.799	0.640	0.030	0.010	0.000
2001	0.062	0.907	0.419	0.011	0.000	0.000
2002	0.000	0.202	0.560	0.177	0.005	0.000
2003	0.000	0.950	0.334	0.258	0.000	0.000
2004	0.032	1.374	0.780	0.184	0.000	0.000
2005	0.000	0.252	0.212	0.000	0.000	0.000
2006	0.000	0.121	0.120	0.002	0.000	0.000

Table E.8 Parametric estimates of biological reference points for Cape Cod-Gulf of Maine yellowtail flounder for the VPA and ASAP models under two priors for unfished recruitment (millions of fish). Fmsy is fully recruited F (ages 4-6), while SSBmsy and MSY are in thousand metric tons.

Model	R prior	Fmsy	SSBmsy	MSY
VPA	none	0.690	3.55	2.09
	10.6	0.530	5.83	2.70
ASAP	none	0.700	3.71	2.15
	10.9	0.550	6.14	2.87

Table E.9 Empirical estimates of biological reference points for Cape Cod-Gulf of Maine yellowtail flounder for the VPA and ASAP models under two time series of recruitment (millions of fish).

Model	R range	Fmsy	SSBmsy	MSY
VPA	1985-2006	0.238	7.74	1.69
	top 15	0.238	10.87	2.37
ASAP	1985-2006	0.243	7.84	1.72
	top 15	0.243	11.24	2.47

Table E.10 Combination approach to setting reference points for the VPA and ASAP models using the Beverton and Holt stock recruitment relationship with priors from the top 15 estimated and hindcast recruitments, but assuming Fmsy is derived from F40%SPR.

Model	R prior	Fmsy	SSBmsy	MSY
VPA	10.6	0.238	11.12	2.43
ASAP	10.9	0.243	11.74	2.58

Figure E.1 Total catch of Cape Cod-Gulf of Maine yellowtail flounder.

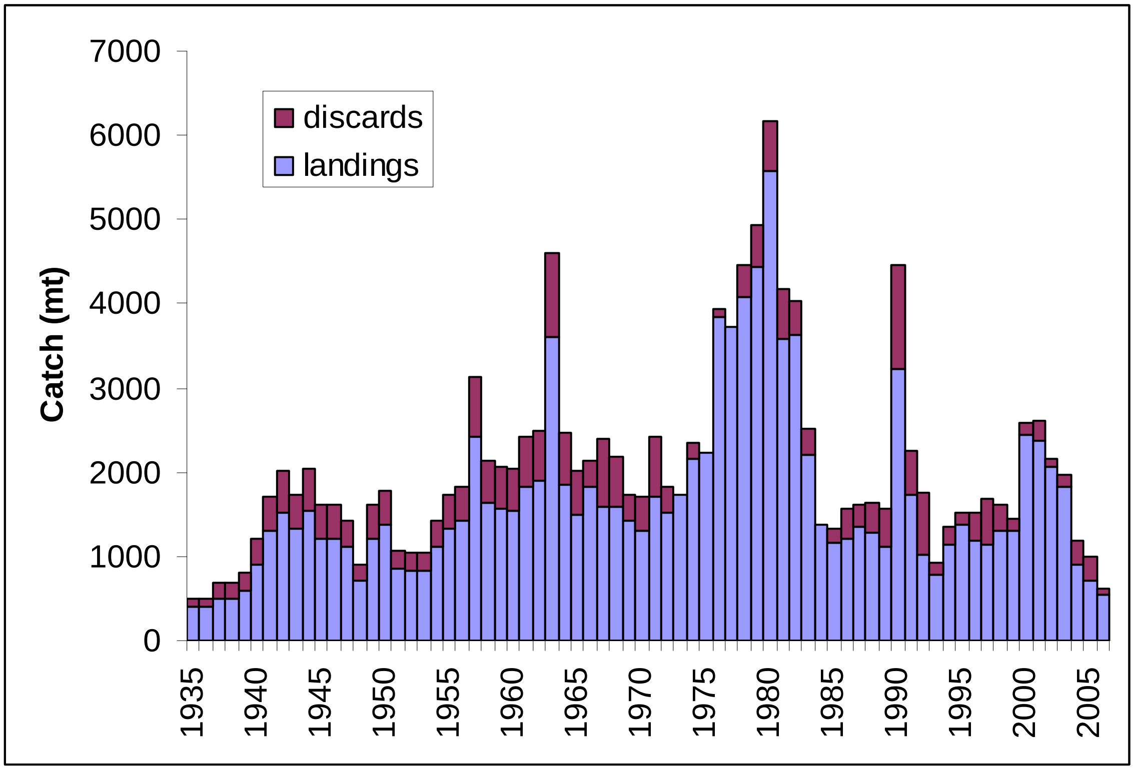


Figure E.2 Trends in survey biomass for Cape Cod-Gulf of Maine yellowtail flounder.

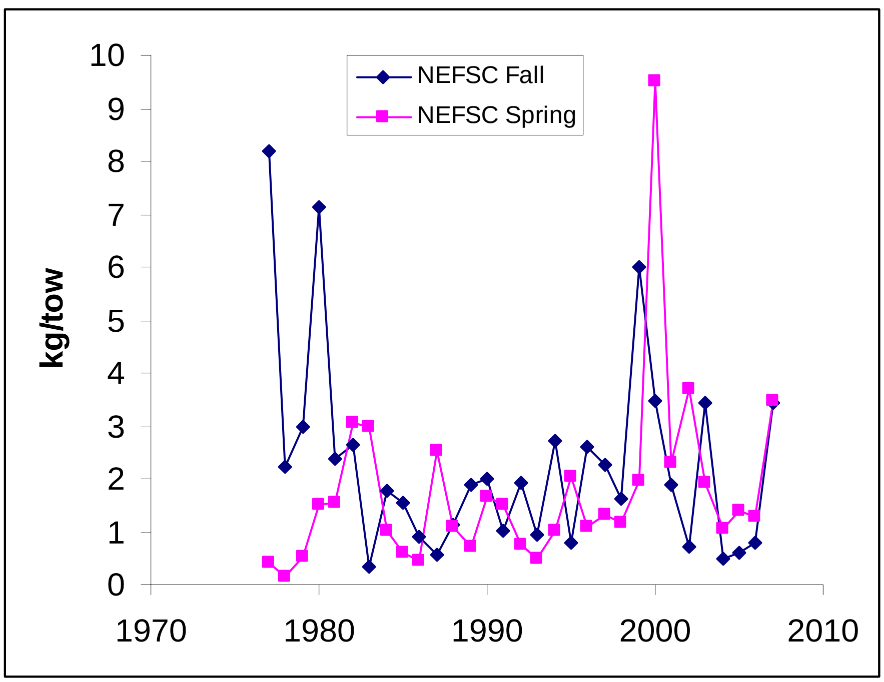
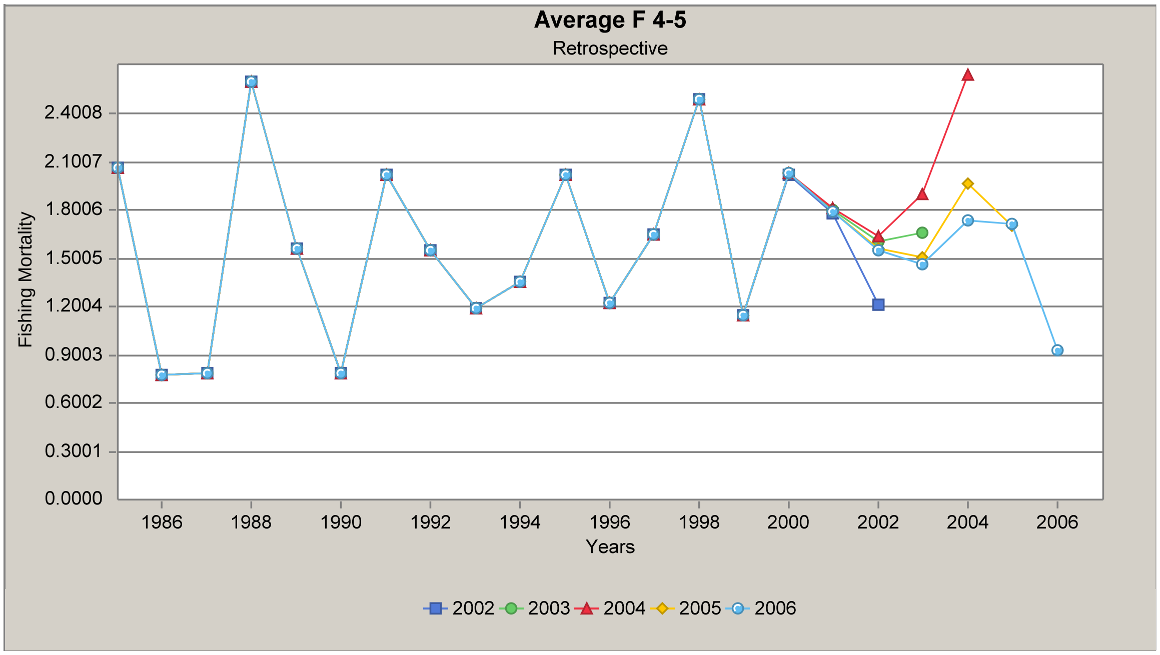


Figure E.3 Retrospective plots of fully recruited fishing mortality rate (ages 4-5) and spawning stock biomass from VPA.



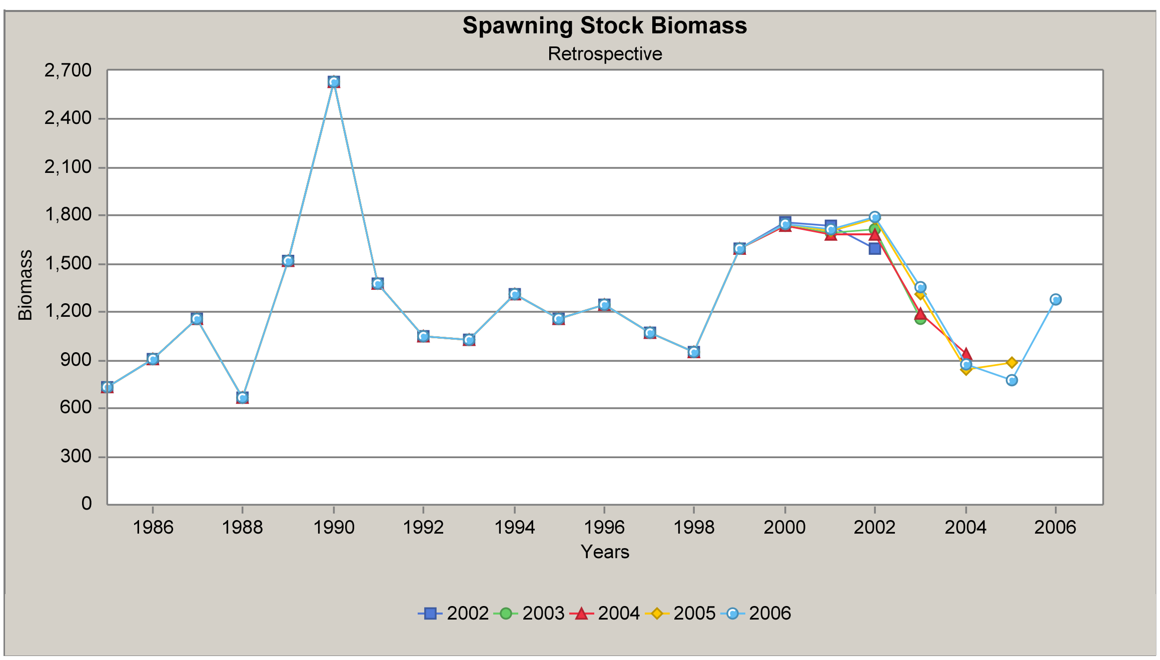
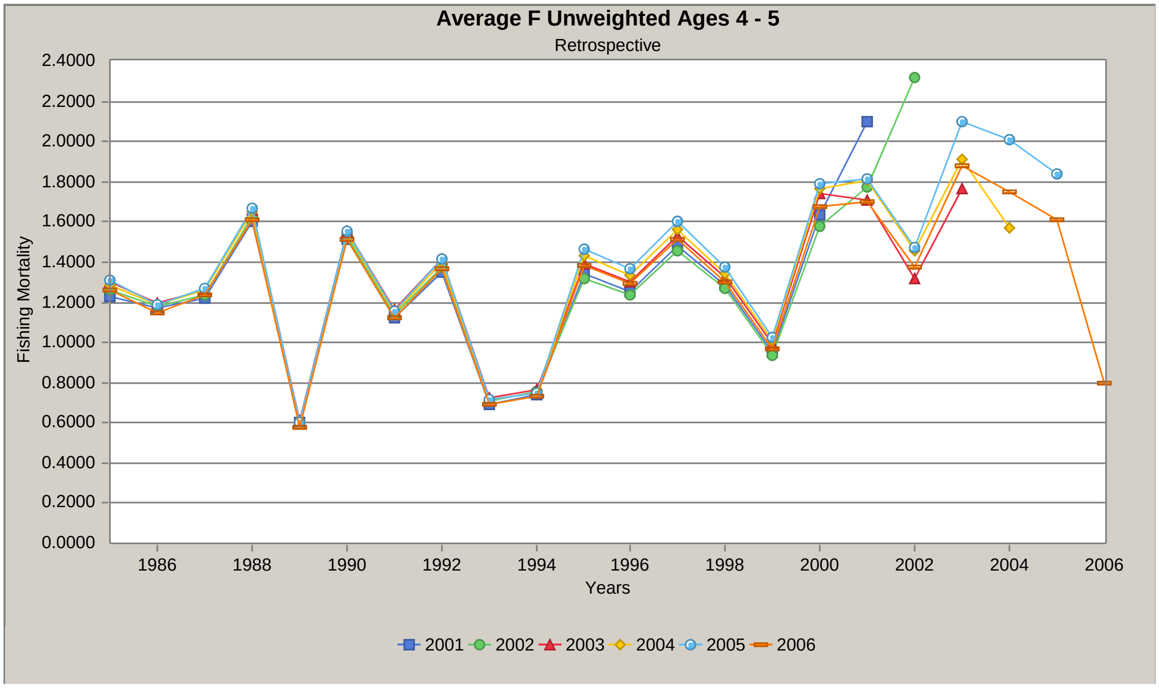


Figure E.4 Retrospective plots of fully recruited fishing mortality rate (ages 4-5) and spawning stock biomass from ASAP.



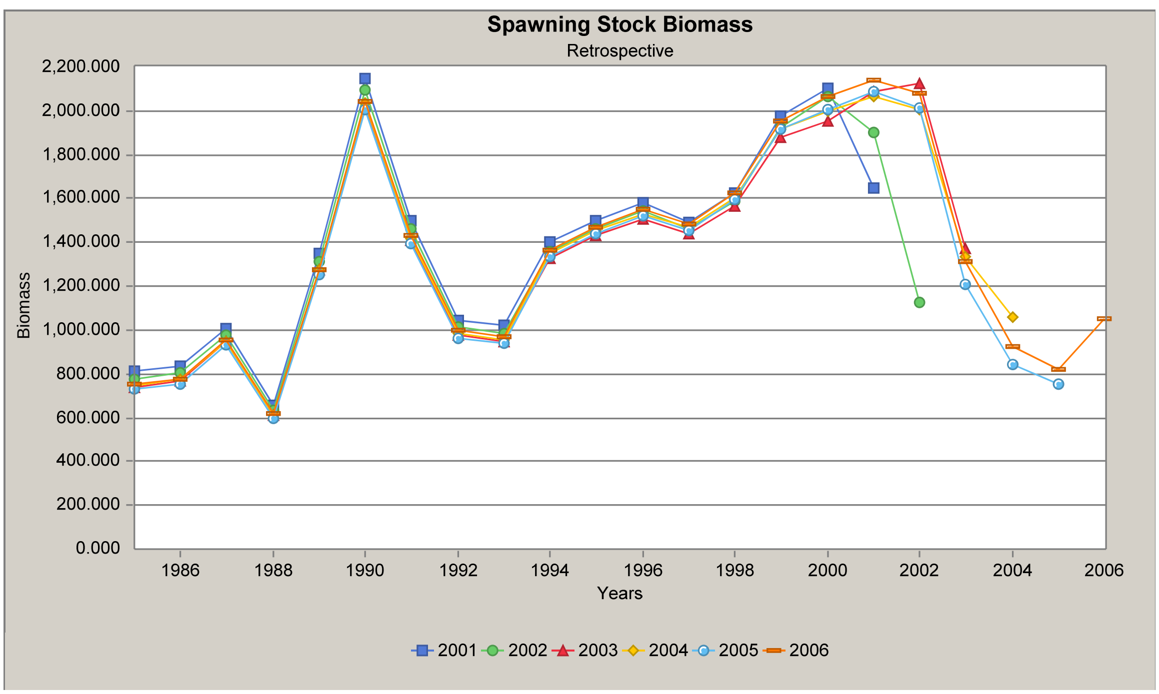


Figure E.5 Stock recruitment relationships from the VPA and ASAP estimates.

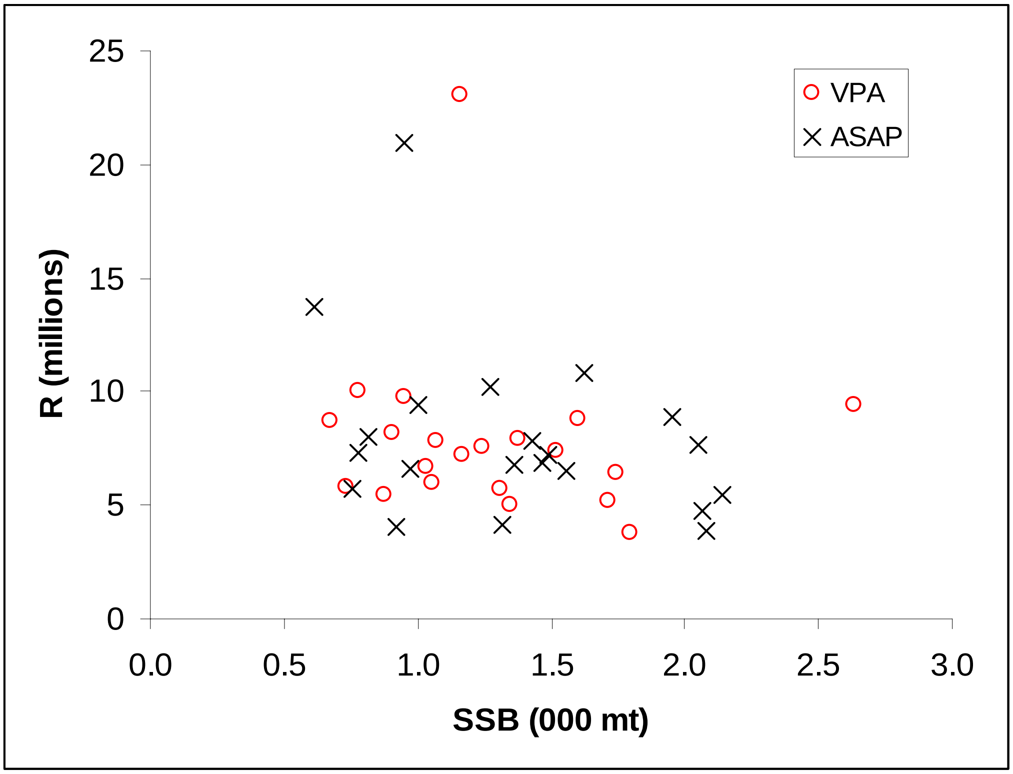
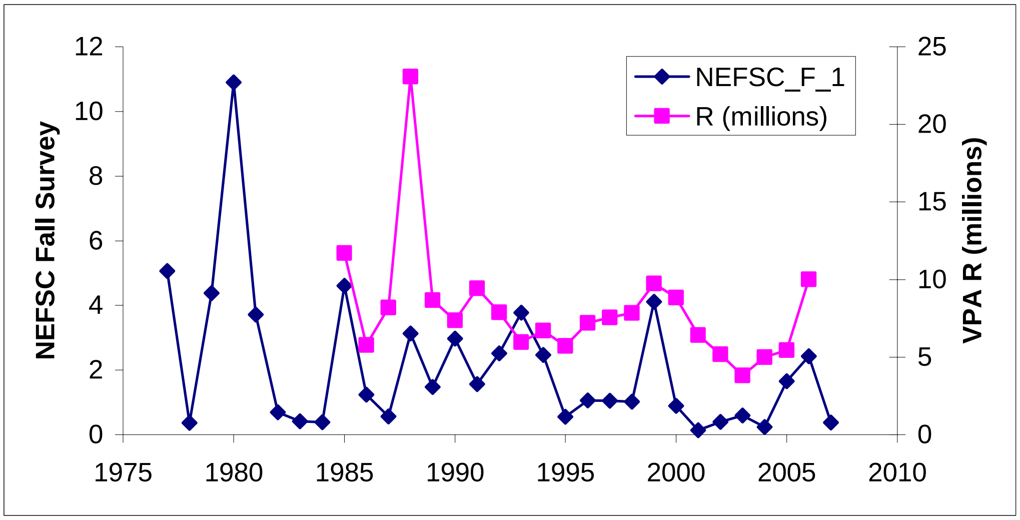


Figure E.6 Hindcast estimates of recruitment using the NEFSC Fall survey at age 1 and the VPA model.



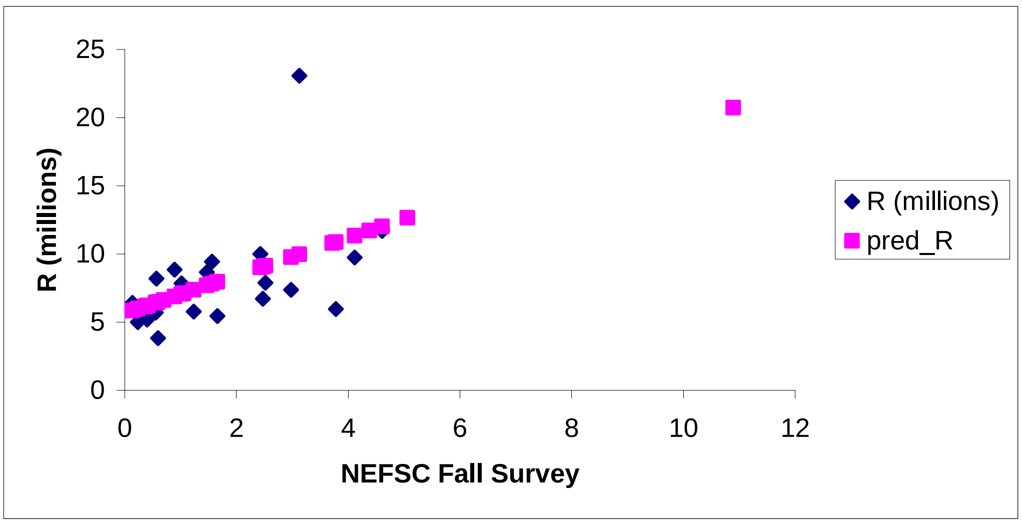


Figure E.7 Hindcast estimates of recruitment using the NEFSC Fall survey at age 1 and the ASAP model.

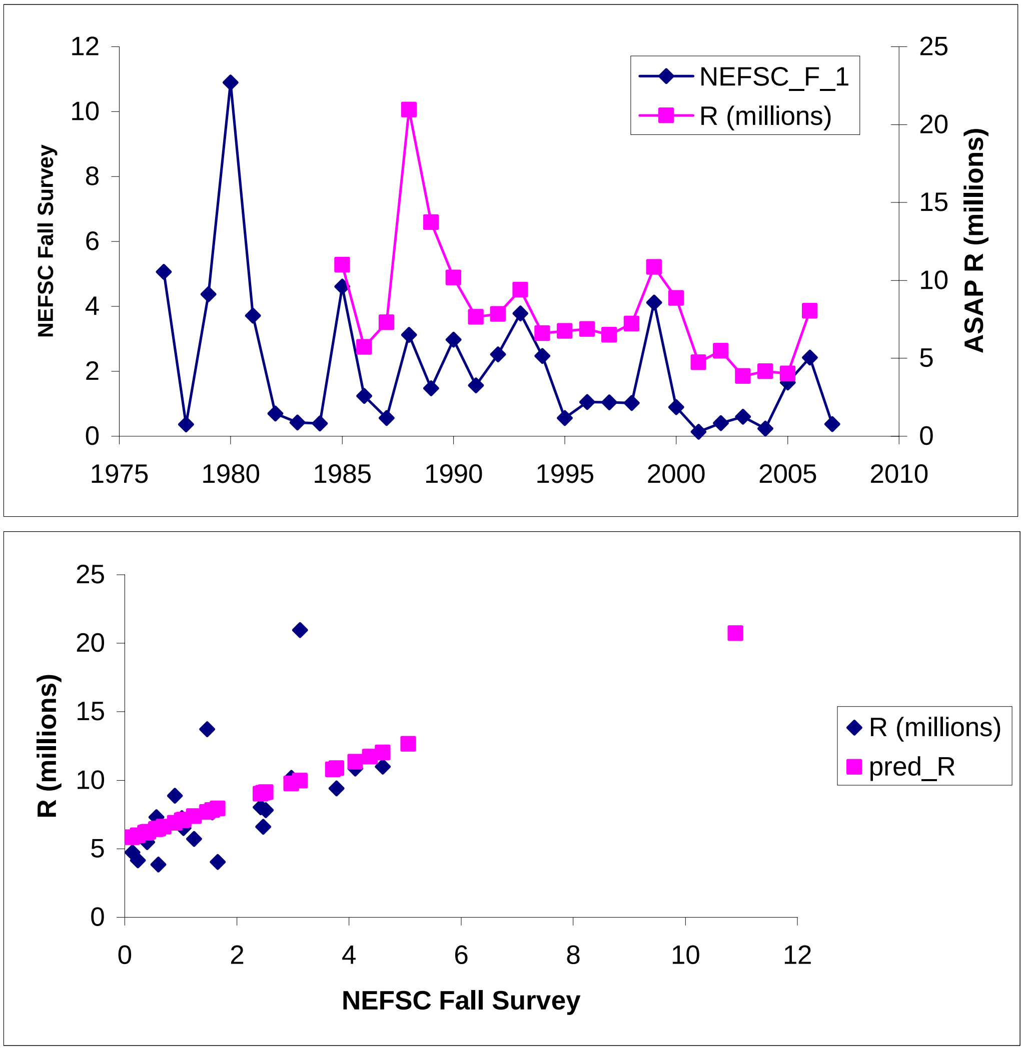


Figure E.8 Current status of Cape Cod-Gulf of Maine yellowtail flounder based on two stock assessment models (VPA and ASAP), parametric (P) or empirical (E) approach to estimating biological reference points, and two levels of recruitment (same symbols, largest recruitment in set of two associated with point farthest to the left).