Virtual Population Analyses of Gulf of Mexico and Atlantic King Mackerel Migratory Groups

Continuity Case and Updated Runs

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1. INTRODUCTION

1.1 Species biology and assessment history

King mackerel (*Scomberomorus cavalla*) typically occur in tropical, subtropical and temperate waters from 20 to 150 feet. They are distributed throughout the western Atlantic from New England south to Brazil. King mackerel are fast-swimming predatory fishes that school, feed voraciously, grow rapidly, mature early and spawn over an extended period of many months. They are highly valued gamefish due to their fast runs and strong fighting ability.

The U.S. commercial fishery for king mackerel began in the 1880's. Historically, the commercial king mackerel fishery utilized gillnets, troll lines, handlines, purse seines, otter trawls, and pound nets. However, the proportion of landings by hook-and-line has increased since the prohibition of purse seines and drift gill nets in 1989. King mackerel are also targeted by an important, year-round sport fishery off many southeastern states. Early recreational landings are thought to have been reduced by the expansion of the commercial runaround gillnet fishery in the 1970's and a driftnet fishery operating off southeast Florida in the late 1980's. Currently, recreational landings comprise 70% of the total landings of king mackerel in the Gulf of Mexico and 50% of the south Atlantic landings.

Results from the most recent stock assessment of the Gulf migratory group (SEDAR5) indicate that the stock is not overfished and that overfishing is not occurring. However, the results should be viewed with some caution. For example, bycatch of Gulf king mackerel in shrimp fisheries is substantial and uncertain. Also, during the most recent years, recruitment was estimated to be higher than average. As year classes with high recruitment move out of the fishery, future stock biomass levels could decline.

The most recent stock assessment of Atlantic king mackerel (SEDAR5) indicated that harvest rates were below the MFMT and overfishing was not occurring as of 2001. That assessment assumed negligible bycatch of Atlantic king mackerel in shrimp fisheries, but it is recognized that the actual level has not been determined with either accuracy or precision.

1.2 Objectives

The primary objective of this document is to present the results of analyses needed to satisfy several terms of reference for SEDAR 16. In particular, this document presents two main types of VPA analyses for each migratory group:

1) A "Continuity Run", where all modeling and data treatment choices are kept as close as possible to those made for SEDAR 5

2) An updated base VPA run using the data treatment and modeling choices agreed to by the SEDAR16 Assessment Workshop, in which the catches of king mackerel within the mixing zone during the winter were assumed to belong 50% to the Gulf and 50% to the Atlantic migratory groups.

Sensitivity runs are also presented that explore other VPA configurations (e.g. 100% of landings in the mixing zone in winter allocated to the Gulf Migratory group and various index weighting options).

2. DATA REVIEW AND UPDATE

Inputs to the VPAs are discussed in Section 3 for each model.

3. STOCK ASSESSMENT MODELS AND RESULTS

The Virtual Population Analysis (VPA) results described in this document provide an update of the previous Gulf king mackerel and Atlantic king mackerel stock assessments (SEDAR5). They represent several analyses including a "Continuity Case" - maintaining continuity in the modeling approach, major assumptions and treatment of the input data while updating the time-series - as well as other analyses conducted following the decisions made by the SEDAR 16 Assessment Workshop.

3.1. Model 1 – "Continuity Case"

3.1.1. Methods

3.1.1.1. Overview

The "Continuity Case" is intended to demonstrate the effect of updated data inputs in isolation - by maintaining continuity in the modeling approach, major assumptions and treatment of the input data while updating the time-series

The "Continuity Case" used the software program VPA-2BOX ver. 3.0.5 May 2004 (Porch, 2003), based on the same algorithms than the F-ADAPT framework. This version of VPA-2BOX is included in the NOAA Fisheries Toolbox package (NFT). To ensure continuity, Atlantic and Gulf "continuity runs" were run using both F-ADAPT and VPA-2BOX with the same inputs and model specifications; both programs provided identical solutions and results[1].

3.1.1.2. Data Sources

[1] S.L. Cass-Calay, pers. comm. NOAA Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL, 33149. Shannon.Calay@noaa.gov.

The data sources and model settings used for the "Continuity Case" are summarized in **Table 3.1**.

Table 3.1. Model settings and inputs used to construct the "Continuity Case".

Settings/Input Series	Continuity Case
Stock Definitions	Catches and indices calculated according to the current migratory stock definition: **ATL stock** - US Atlantic north of Volusia County, FL during Nov – Mar, Monroe County FL and northward during Apr– Oct. **GOM stock** - US Gulf of Mexico from Texas to Collier County, FL during Apr - Oct and to Volusia County, FL during Nov- Mar.
Fishing Year	Like SEDAR5, catch and Indices estimated using "fishing year" definitions.
Directed Landings/Discards	Like SEDAR5, only retained catch (AB1) for recreational fisheries. No recreational or commercial discards. Used updated series.
Shrimp Bycatch	Used "GLM5A" estimates developed by SEFSC (5/2008) to replicate SEDAR 5 estimation procedure.
Catch-at-age	Age length keys were developed using SEDAR5 methods and inputs, including the von Bertalanffy growth parameters and sex-at-size ratios (1985-1998, using 1998 sex ratios for all subsequent years).
Weight-at-Age	Same vector of weight at age as used in SEDAR5.
Indices of Abundance	Used same indices selected for SEDAR5 assessment. In general, used identical methods to update indices through 2006.
Natural Mortality	Like SEDAR5, constant natural mortality rate M: 0.20 for GOM king, and 0.15 for ATL king
Terminal Year F-at-age	Like SEDAR5, $F_{0,2006}$ and $F_{1,2006}$ were fixed relative to the estimated $F_{2,2006}$ using ratios derived from a separable VPA (2000-2006).
Annual F-Ratio	Like SEDAR5, for each year F_{10} : F_{11+} was fixed at 1.0. This implies that the fishing mortality rate on the plus group is equal to the fishing mortality rate on age 10.

The biological functions used during the continuity runs are summarized in **Table 3.2**.

Table 3.2. Values of natural mortality, weight, maturity and fecundity, by age, used for the F-ADAPT and VPA2-BOX continuity cases.

	Natural Mortality		Weight-at-age (kg)		Proportion Mature		Fecundity (millions of eggs)	
Age	Atlantic	Gulf	Atlantic	Gulf	Atlantic	Gulf	Atlantic	Gulf
0	NA	0.20	NA	0.469	NA	0.000	NA	0.024
1	0.15	0.20	1.263	1.123	0.548	0.157	0.155	0.093
2	0.15	0.20	1.853	2.005	0.861	0.529	0.266	0.229
3	0.15	0.20	2.486	3.037	0.924	0.704	0.406	0.437
4	0.15	0.20	3.131	4.144	0.948	0.856	0.570	0.714
5	0.15	0.20	3.767	5.266	0.970	0.989	0.753	1.048
6	0.15	0.20	4.379	6.364	0.989	1.000	0.947	1.425
7	0.15	0.20	4.955	7.412	1.000	1.000	1.149	1.829
8	0.15	0.20	5.493	8.319	1.000	1.000	1.352	2.247
9	0.15	0.20	5.986	9.285	1.000	1.000	1.553	2.667
10	0.15	0.20	6.437	10.106	1.000	1.000	1.748	3.079
11+	0.15	0.20	7.213	14.061	1.000	1.000	2.367	4.312

VPA models assume that the catch-at-age matrix is known without error. The catch-at age of the Atlantic and Gulf king mackerel stocks are summarized in **Tables 3.3 and 3.4**.

Table 3.3. Catch-at-age for Atlantic king mackerel.

	Directed Landings										
YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
1981	13633	60292	64301	115145	103317	108451	73666	105276	33917	26758	62377
1982	5714	11390	12672	56607	105516	149445	164766	93819	66322	52740	139537
1983	10107	34123	77181	100404	77042	123668	119771	143300	26963	22815	154643
1984	14436	8122	14189	61017	98677	142380	132547	86039	38250	25693	165583
1985	24876	117534	98381	34598	104993	96583	95992	226992	72032	17100	151460
1986	41651	74224	84850	119231	109629	85963	89693	122968	69290	18710	139633
1987	139373	190407	107954	102628	85981	62012	23146	57059	22207	11296	87717
1988	13984	161467	215515	126776	39802	41599	56414	26770	72153	22908	119144
1989	47211	65847	109443	97248	72683	57630	36024	26306	18930	62683	69582
1990	104520	109594	75043	96099	89306	70740	34816	20443	34883	20312	93730
1991	50499	257111	116424	62895	114734	110663	51756	50281	15859	9644	93896
1992	39018	178061	296388	87737	59266	56119	63462	28159	21040	18605	91410
1993	23860	60187	99594	119137	46862	35100	43097	53454	26999	20922	64370
1994	43688	107423	50982	88866	106194	52253	29640	26850	38609	22912	40151
1995	67840	135257	73517	53233	64394	97460	30395	21769	28134	26553	45073
1996	27824	151179	103183	96631	66290	56098	89073	24950	22042	17625	42221
1997	61760	224676	137777	95705	59664	37643	52940	58536	23437	8125	48245
1998	26937	127272	171902	123827	74526	43181	23701	44701	49382	6554	33263
1999	47057	77797	114833	140694	75671	41986	18563	18441	26981	27383	20102
2000	3514	221176	101921	164524	112157	48038	19355	10049	12291	28013	51288
2001	6186	50087	118696	77489	100201	59327	30521	14599	7702	10724	55201
2002	31876	51885	61041	117858	42919	60948	27496	20975	8422	2909	24888
2003	9044	154403	59793	86378	133868	44167	64272	33181	12678	4536	21211
2004	34120	100410	160553	56787	77178	107648	23057	45242	16173	9092	19734
2005	1348	14216	55614	132452	146374	90724	29504	62240	23739	6899	87596
2006	9812	116468	239978	94117	142335	20824	15408	45739	5070	19054	31344

Table 3.4. Catch-at-age for Gulf king mackerel.

	Shrimp Bycatch	Directed Landings											
YEAR	Age 0	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
1981	356108	0	50391	51144	44216	428392	235791	58227	44287	14226	7592	5313	13224
1982	331288	166067	9751	65542	213621	183622	342467	90285	41535	59907	13264	8775	76533
1983	310101	2600	9492	102918	270109	166061	61699	49021	31031	14305	4842	4591	14124
1984	470246	0	45182	20807	65611	321113	132349	52595	49778	19269	7931	1839	7575
1985	446584	0	13780	26514	66748	174752	123953	82498	39552	10389	7883	3631	11343
1986	311207	14755	55424	199470	131558	49015	69622	43597	21738	10296	5791	2728	10582
1987	712826	1339	27999	88899	150090	42995	57142	24914	7896	5849	8188	2199	4030
1988	504022	816	26809	46062	65727	160053	165593	60909	56677	23474	8360	5715	27135
1989	1222068	1000	115989	173584	158141	76439	74613	32011	22098	16023	8270	4545	15044
1990	807398	13944	48125	121594	156996	205458	51404	46062	20264	25970	9920	2247	16769
1991	1005278	2353	194291	330533	161343	92990	64019	40349	20108	6748	23577	9135	15548
1992	501309	774	98619	188687	185921	268585	90605	82229	32308	16217	26182	25105	26988
1993	1093016	1664	119052	136072	173923	192614	142038	51479	55831	26792	8718	2156	41754
1994	954911	710	154107	120056	149738	231319	218676	79105	32614	59179	29152	13402	34138
1995	1083320	2069	69025	256263	185202	113355	84577	88213	50946	21487	10591	17292	25746
1996	554116	0	67438	343504	223813	116603	68726	53846	46779	46305	18078	3801	43262
1997	697331	0	63889	268686	322450	169135	97767	43695	44039	40715	27301	10220	21960
1998	655095	0	83169	140340	248661	218935	122437	58717	31486	34899	37082	13118	13660
1999	586793	0	89602	141263	143686	183899	106258	40667	29184	15502	27007	10294	16535
2000	720777	31135	68634	180731	208913	159734	104986	47014	42169	16518	21539	13697	29045
2001	567341	64	62547	153678	237624	153873	80419	61163	52343	35193	16943	7889	31707
2002	541081	8935	91720	291758	187809	169334	93531	57248	37102	30974	17279	10531	23627
2003	576742	221	35757	183522	159924	161309	117104	66227	32187	28545	21245	15620	21922
2004	1003087	47706	32313	266067	167754	135413	76242	64612	37046	14913	20558	11146	18631
2005	626742	46870	20772	189194	156244	193882	103584	60674	51177	36660	13223	13671	31881
2006	444788	0	31992	209801	271108	251255	134308	77371	45797	36122	16240	9040	29043

The Atlantic continuity runs used 5 indices of abundance (**Table 3.5**) to tune the VPA estimates, while the Gulf run used 9 (**Table 3.6**). For the Gulf continuity run, 3 indices used by the previous SEDAR5 panel could not be updated during the SEDAR16 data workshop: 1) the Texas Parks and Wildlife Department, 2) Charter Boat SW FL and 3) Charter Boat NW FL indices. Thus, these are included unchanged from the estimates provided for SEDAR5. It should also be noted that the index CVs were not used directly. Instead, the index variances were estimated using a concentrated maximum likelihood procedure.

Table. 3.5. Indices of abundance and index settings used for the Atlantic continuity runs.

	MRFSS-ATL		HB-Atl. Migratory		Trip Ticket - NC PIDs 8+		Trip Ticket Cont- FL Atl Coast		SEAMAP S. Atl Trawl Survey	
Type of Index	Fish. Dep. REC		Fish. Dep. REC		Fish. Dep. COM		Fish. Dep. COM		Fish. Independent	
Unit	Numbers		Numbers		Biomass		Biomass		Numbers	
Applied to Ages	Ages 2-11		Ages 1-8		Ages 2-11		Ages 2-8		Age 1	
Index Timing	Mid-Year		Mid-Year		Mid-Year		Beginning-Year		Mid-Year	
YEAR	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV
1981	1.010	0.545	0.912	0.308						
1982	1.386	0.452	0.788	0.297						
1983	1.350	0.469	0.845	0.278						
1984	1.275	0.453	0.969	0.265						
1985	1.374	0.474	0.564	0.286						
1986	1.912	0.410	0.761	0.273			1.024	0.007		
1987	1.269	0.417	1.287	0.259			0.986	0.007		
1988	0.952	0.409	0.869	0.281			1.169	0.007		
1989	0.748	0.411	0.624	0.292			1.030	0.008	0.807	0.212
1990	1.171	0.410	0.744	0.277			0.927	0.008	2.377	0.158
1991	1.089	0.403	1.545	0.250			0.898	0.007	0.704	0.222
1992	1.112	0.399	1.407	0.245			0.833	0.008	0.843	0.241
1993	0.640	0.414	0.844	0.261			0.850	0.007	0.446	0.247
1994	0.551	0.412	1.041	0.257	0.700	0.068	0.832	0.008	0.708	0.232
1995	0.658	0.406	0.935	0.257	0.744	0.073	0.780	0.008	1.226	0.198
1996	0.768	0.402	0.626	0.275	1.125	0.069	0.965	0.007	2.261	0.168
1997	0.993	0.401	1.129	0.261	1.033	0.060	0.970	0.007	0.519	0.240
1998	0.891	0.399	0.911	0.269	1.056	0.060	0.981	0.007	1.786	0.200
1999	0.824	0.401	1.163	0.262	0.969	0.061	0.992	0.007	1.213	0.184
2000	1.037	0.395	1.852	0.250	0.986	0.059	0.863	0.007	0.816	0.221
2001	0.592	0.401	1.215	0.267	1.044	0.057	0.905	0.007	0.448	0.234
2002	0.722	0.400	0.979	0.273	0.907	0.069	0.826	0.008	0.506	0.211
2003	0.750	0.403	0.838	0.280	0.879	0.073	1.093	0.007	0.989	0.196
2004	0.987	0.398	0.715	0.279	1.292	0.058	1.294	0.007	0.619	0.357
2005	0.999	0.399	1.200	0.271	1.206	0.063	0.974	0.007	0.726	0.493
2006	0.939	0.406	1.238	0.269	1.058	0.066	1.463	0.007	1.006	0.221

Table 3.6. Indices of abundance and index settings used for the Gulf continuity runs.

	MRFSS - GULF		HB-Gulf Migratory		Trip Ticket Cont-Panhandle ***(Rescaled to 81-06 period)***		Trip Ticket Cont-SW FL		Shrimp Bycatch ***(Rescaled to 81-06 period)***	
Type of Index	Fish. Dep. REC		Fish. Dep. REC		Fish. Dep. COM		Fish. Dep. COM		Fish. Dep. COM	
Unit	Numbers		Numbers		Weight		Weight		Numbers	
Applied to Ages	Ages 2-8		Ages 2-6		Ages 3-6		Ages 3-8		Ages: 0	
Index Timing	Beginning-Year		Mid-Year		Mid-Year		Mid-Year		Beginning-Year	
YEAR	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV
1981	0.6701	0.4054	1.4620	0.3280					0.1461	0.7878
1982	0.3601	0.4031	0.8650	0.3400					0.0728	0.8595
1983	0.8004	0.3596	1.9420	0.3040						
1984	0.4173	0.4014	0.6200	0.3510					0.3705	0.5106
1985	0.4266	0.3887	0.4450	0.2990					0.2524	0.5094
1986	0.4539	0.3196	0.4890	0.2520	0.7862	0.0520	0.3850	0.0220	0.1012	0.7533
1987	1.0693	0.2858	0.3240	0.2860	0.5480	0.0370	0.5900	0.0170	0.4624	0.4676
1988	0.6765	0.2985	0.3790	0.2770	0.5228	0.0250	0.8170	0.0220	0.4709	0.4312
1989	0.9378	0.3050	0.6120	0.2540	0.3663	0.0480	0.7640	0.0140	1.2882	0.4062
1990	1.2820	0.2862	0.5040	0.2640	0.5460	0.0300	1.0000	0.0120	1.0238	0.3660
1991	1.1803	0.2777	0.7970	0.2420	0.5480	0.0230	1.0180	0.0130	1.1284	0.4051
1992	1.2209	0.2655	1.0280	0.2340	0.7508	0.0190	2.3680	0.0100	0.4203	0.3282
1993	1.1378	0.2725	1.2300	0.2300	0.6529	0.0240	1.0630	0.0120	1.4018	0.2405
1994	1.4390	0.2630	1.1170	0.2270	0.8073	0.0140	0.6630	0.0170	1.3633	0.3091
1995	0.9981	0.2849	1.0780	0.2370	0.7973	0.0180	0.9420	0.0140	1.8245	0.3122
1996	1.3496	0.2708	1.6730	0.2240	1.4482	0.0090	1.1060	0.0110	0.6279	0.3962
1997	1.6397	0.2590	1.3170	0.2260	1.9023	0.0080	0.9300	0.0130	0.8419	0.3549
1998	0.9055	0.2646	1.0830	0.2310	1.2786	0.0120	1.0310	0.0160	0.7904	0.3766
1999	0.8820	0.2630	1.1270	0.2290	1.4734	0.0100	0.6520	0.0180	0.7383	0.3411
2000	1.1231	0.2558	0.9670	0.2350	1.2918	0.0110	1.1700	0.0160	0.8657	0.3540
2001	1.0189	0.2587	1.1520	0.2340	1.5663	0.0100	1.2440	0.0160	1.5748	0.3483
2002	1.3102	0.2531	1.1640	0.2310	1.2302	0.0130	0.8850	0.0190	0.7913	0.3835
2003	0.9135	0.2624	0.9610	0.2440	1.0829	0.0130	1.1300	0.0150	2.6647	0.3375
2004	1.0046	0.2598	1.0960	0.2400	1.0284	0.0180	0.8800	0.0190	3.0187	0.3379
2005	0.9180	0.2642	1.3780	0.2320	1.0718	0.0220	1.4070	0.0150	0.8233	0.4308
2006	1.8647	0.2703	1.1910	0.3000	1.3008	0.0140	0.9550	0.0190	1.9364	0.3381

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Table 3.6. – Continued.

	SEAMAP Fall Plankton (Larval)		Texas Parks and Wildlife Deparment		Charter Boat SW FL		Charter Boat NW FL	
Type of Index	Fish. Independent		Fish. Dep. REC		Fish. Dep. REC		Fish. Dep. REC	
Unit	Numbers		Numbers		Numbers		Numbers	
Applied to Ages	SSB = Ages 1- 1+		Ages 2-8		Ages 3-8		Ages 2-6	
Index Timing	Beginning-Year		Beginning-Year		Mid-Year		Beginning-Year	
YEAR	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV
1981								
1982								
1983								
1984								
1985								
1986	0.1160	0.5341	0.7439	0.2039				
1987	0.3788	0.3219	0.8695	0.2009				
1988	0.6130	0.4365	0.7834	0.1999	0.7913	0.0817	0.8929	0.1008
1989	0.8450	0.3255	0.8733	0.1996	1.0462	0.0817	0.8819	0.0698
1990	0.6480	0.3211	0.6760	0.2115	0.8940	0.0817	0.8803	0.0600
1991	0.7212	0.3181	1.5325	0.1689	0.7323	0.0817	0.9510	0.0600
1992	0.5960	0.2372	1.0679	0.2005	0.9435	0.0817	0.9989	0.0690
1993	1.2505	0.1987	1.0339	0.1962	1.0652	0.0817	0.9305	0.0777
1994	1.0500	0.2310	1.0788	0.1924	1.5274	0.0817	1.2008	0.0904
1995	1.9787	0.1947	1.3004	0.1764			1.2637	0.1262
1996	0.7407	0.2647	1.2896	0.1761				
1997	1.3597	0.2007	1.0468	0.2014				
1998			1.1751	0.1912				
1999	0.9198	0.2249	0.9473	0.2151				
2000	0.9219	0.2730	0.8052	0.2165				
2001	1.6424	0.2026	0.7764	0.2306				
2002	1.4511	0.2143						
2003	1.1027	0.2190						
2004	1.4780	0.2108						
2005								
2006	1.1865	0.2533						

For most indices, selectivity (*S*) by age and year was estimated using partial catches (CAA by year corresponding to each index of abundance). In the Atlantic there was one exception, the SEAMAP South Atlantic Trawl survey. This survey was assumed to index the abundance of age-1 king mackerel (SEDAR16-Data Report). Therefore, for all years, $S_1$was fixed to 1.0 and $S_{2\text{-}11+}$

were fixed to 0.0. In the Gulf, there were two exceptions: the Shrimp Bycatch GLM which was assumed to index age-0 king mackerel ($S_0$was fixed to 1.0 and $S_{1\text{-}11+}$ were fixed to 0.0) and the SEAMAP Ichthyoplankton survey, which was assumed to index spawning stock biomass. For this index, the selectivity pattern was fixed at maturity*fecundity-at-age. The partial catches used to estimate selectivity for each index are summarized in **Tables 3.7 and 3.8**. . Like the SEDAR F-ADAPT runs, the partial catches were fit using the Powers and Restrepo (1992) method which allows selectivity to vary by year and matches the partial catch at age exactly.

Table 3.7. Partial catches at age (numbers) used in the Atlantic continuity model runs.

Index	Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
NC Trip Ticket	1981	2523	5753	37972	8720	10270	1974	10370	777	1015	1972	2331
	1982	2090	4833	1895	11835	9100	15352	9014	18198	693	1823	37146
	1983	1028	2917	2923	4295	8721	11157	13269	16206	2207	6612	16181
	1984	321	886	1720	2523	2205	8074	10561	7582	7817	2192	17118
	1985	4961	1013	5314	5537	4779	5914	6907	15444	8167	3736	15751
	1986	9193	4033	7765	7622	15599	9773	13072	7374	7333	1427	21780
	1987	4474	9105	21346	20912	17805	12867	5897	12656	5070	2793	19392
	1988	507	9600	19454	14509	5770	5104	7116	2865	7633	2923	10412
	1989	4192	13050	17541	14518	10479	10841	7987	2694	3981	7059	5831
	1990	9516	22930	17466	23113	20275	16029	8663	3305	10077	4037	13561
	1991	2274	28790	20688	11414	20111	18367	6019	10143	1187	674	7996
	1992	1610	20254	46266	19150	9390	7122	7458	4604	2546	1772	6100
	1993	1852	7968	14498	18991	7968	5254	5067	5926	3409	2213	5450
	1994	1625	10200	5958	9888	15211	10202	8876	4606	8721	5395	10196
	1995	1637	7435	10120	8749	10174	17404	6879	4147	4226	4610	6370
	1996	2751	13304	19716	30155	26209	16138	21453	5301	3909	5097	4500
	1997	4601	22989	19846	16040	10454	6752	7781	9626	4900	1435	6652
	1998	1281	19723	37962	25485	18647	16383	5169	7069	7266	671	4754
	1999	5405	16368	23805	27311	15601	10586	4386	4313	4302	2591	2483
	2000	521	14459	11178	22630	15873	8939	3400	3105	2595	2703	6013
	2001	975	6412	13121	7972	12898	9059	7053	4433	2705	1475	11623
	2002	4039	8275	10596	17133	7176	12444	3886	4752	3350	519	5645
	2003	543	14502	6063	8159	12667	3950	6027	2646	1737	326	2576
	2004	9340	35177	35466	15359	17076	15513	1822	7917	849	404	3077
	2005	0	3686	12693	32169	28191	24729	503	14581	3809	2129	16207
	2006	987	21437	36868	14014	21720	6625	3157	5923	1006	3150	7836
FL Atl. Trip Ticket	1981	342	800	5973	25943	21588	39868	22145	17505	17899	10346	11885
	1982	556	507	1956	7669	22575	52990	47988	16824	34389	17579	26406
	1983	251	1825	10789	12868	4260	4641	6941	29416	3874	296	44106
	1984	0	807	674	8398	20058	9444	8798	25302	7242	4499	21631

	1985	127	1582	1897	6895	18630	17800	25092	27639	5759	2781	30982
	1986	1397	1316	2574	6074	13236	20329	19055	15259	35341	2825	26993
	1987	14127	29753	25869	25716	23142	17538	6076	16505	6377	3146	25842
	1988	2115	41860	56207	33551	9079	11432	14558	7747	19603	6277	35064
	1989	6923	13679	26173	25001	19051	14359	7028	7451	4403	18657	22627
	1990	9574	17638	13397	16670	17319	15051	8048	5372	7351	4590	23175
	1991	7203	31084	15729	7505	16367	16554	9252	7332	2460	1310	15836
	1992	6950	25682	33819	8672	6593	5823	6212	3065	2377	1957	10700
	1993	5793	16385	29570	29005	8134	6846	7103	8694	4790	3911	7789
	1994	8141	21249	12423	21816	24513	10624	4869	5332	7304	4789	5608
	1995	3738	8387	8304	8427	11091	17666	6164	4460	6593	5300	8511
	1996	9734	49866	22834	17476	9968	9700	18156	5253	3819	1734	7039
	1997	11208	68953	28908	16801	9741	5100	8542	8473	2966	1113	6780
	1998	3566	20766	38457	26098	13662	5946	3588	8261	8654	1151	4264
	1999	6578	13987	24057	30078	16341	8309	3898	4070	6524	6824	4153
	2000	357	29704	17036	30740	20458	7696	3032	941	1519	4333	5400
	2001	1056	10599	29611	20257	23356	12799	3766	1891	1139	1814	5810
	2002	4329	9492	12644	26175	9386	12730	6326	4255	1377	612	5125
	2003	1111	25237	10635	16538	25530	8606	12337	6371	2269	785	4310
	2004	3852	19836	40530	13877	20757	32411	6493	11939	3402	1660	3447
	2005	734	2191	2468	14661	22937	10420	5040	10635	1962	11	34716
	2006	1469	18061	51973	22721	37676	4958	4143	15760	1609	6622	7123
MRFSS	1981	5371	49101	10705	56691	54369	40899	36702	70637	12965	13679	38720
	1982	2549	5521	7267	27836	62698	71341	101516	47711	30698	33151	65588
	1983	7001	27747	62491	81083	58870	68564	86416	77906	19358	3531	67604
	1984	13396	5692	9707	47668	72299	121614	88307	51197	13391	17356	102662
	1985	17374	95832	68358	13992	61826	58590	45060	138752	49354	7451	76074
	1986	16699	45572	46055	73158	48525	30580	26737	39422	16372	3752	38950
	1987	101310	124805	44359	38662	29153	19722	6772	16420	6610	3119	25229
	1988	8208	75243	89929	48467	12821	13691	19490	9094	24946	7643	41670
	1989	22529	24004	39715	35076	25914	18614	9496	9097	5794	23752	24331
	1990	72038	50639	32698	40125	36498	27027	12334	8315	11580	8078	40151
	1991	25208	123036	48744	20747	39819	39081	22033	16198	7140	4739	39678
	1992	20688	88573	137772	35181	25787	25524	29174	11541	9190	8231	41499
	1993	11389	22958	38155	46844	18268	14695	21389	26975	12558	10049	37530
	1994	27247	57022	23071	40985	46895	21778	10423	12383	15602	8820	17154
	1995	54193	101452	45320	28449	33344	45785	12285	9220	12668	12094	19459
	1996	10191	61357	43193	34952	21829	21133	32870	10592	6652	5402	16110
	1997	30274	98037	65409	46184	29326	19983	27962	31281	10883	4411	27710
	1998	12969	55826	66436	49455	28099	13077	9595	18362	21754	3170	16720
	1999	27503	38667	57160	71451	36952	18947	8432	8273	13131	14899	10356

	2000	2109	141405	60507	91714	61348	25036	10382	4815	6573	16840	28809
	2001	3533	28519	65908	42932	55789	32451	16737	6702	3353	6479	31695
	2002	21117	30288	33727	66261	23195	30953	15037	10240	3095	1514	11960
	2003	6290	101580	39689	57728	89063	29455	42474	22672	7638	3225	12896
	2004	18362	39129	76091	24433	34842	53402	13044	22336	10427	6134	11361
	2005	589	6389	30792	69833	83611	44127	22506	30175	14622	4175	30667
	2006	6607	69153	138245	52761	76251	8289	7362	22111	2147	8545	14443
Headboat	1981	3654	46668	8337	52884	48887	39155	27001	59766	8657	11088	26911
	1982	1617	3433	4415	17035	18267	26012	17342	18012	6376	1125	23707
	1983	5894	19032	10755	14783	25412	31570	41114	41780	2934	1088	33380
	1984	2150	3656	6371	12863	28045	27464	44091	13995	12259	13727	37694
	1985	11609	78588	54013	6462	47103	48130	31688	134240	42792	5233	68933
	1986	299	1015	1639	2533	2355	3131	5152	3270	3027	1840	3780
	1987	3051	5549	4231	4125	3596	2418	710	1963	809	352	2624
	1988	270	3470	4532	3049	945	1192	1597	736	2118	615	3549
	1989	4599	3867	4092	3041	2006	1381	681	645	395	1709	1606
	1990	3446	5252	3110	3906	3459	2457	1104	689	885	567	2990
	1991	5606	17687	5284	1957	3389	2770	1373	915	277	169	1869
	1992	1521	5837	7360	1825	1358	1176	1272	569	394	319	1531
	1993	2045	4298	4346	4497	1318	1026	1084	1221	518	388	703
	1994	3830	7553	2653	3745	3491	1293	520	566	657	350	423
	1995	3036	4925	2245	1473	1784	2339	630	427	660	512	677
	1996	1313	8143	5626	4162	2675	2286	3541	1127	699	562	1443
	1997	2179	5781	2725	1929	1246	778	1220	1295	442	140	937
	1998	1407	4187	3895	2484	1301	549	348	786	764	100	351
	1999	3845	4841	3641	3297	1572	766	344	312	552	553	334
	2000	111	7811	2903	3890	2534	883	340	125	178	477	735
	2001	224	1654	3577	2174	2314	1126	407	169	96	129	546
	2002	1516	1880	1515	2829	938	1253	581	384	115	75	446
	2003	289	3374	955	1126	1631	469	611	303	108	44	154
	2004	964	2799	3472	992	1360	2071	431	790	278	158	294
	2005	4	823	3316	4338	3192	3077	1122	2254	779	429	2134
	2006	144	3376	6597	2229	3065	221	203	669	63	198	601

Table 3.8. Partial catches-at-age (numbers) used in the Gulf continuity model runs.

Index	Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
Trip Ticket FL Panhandle	1981	0	0	0	580	1664	751	654	52	5	16	0	110
	1982	141	2	278	578	1317	171	16	720	0	300	0	111
	1983	0	0	1288	3149	338	191	251	73	180	91	38	71
	1984	0	0	5	386	2273	247	243	26	69	32	25	9
	1985	0	0	3	19	372	435	46	60	18	0	3	1
	1986	0	3	209	552	20	33	94	24	15	1	0	8
	1987	0	850	2058	651	177	299	79	47	17	10	4	17
	1988	0	12	158	698	525	307	91	65	126	7	0	66
	1989	7	1482	4835	710	748	473	7	14	8	4	9	24
	1990	0	392	1450	1213	444	157	141	175	51	14	14	33
	1991	25	2567	3537	1289	669	534	325	122	30	310	49	114
	1992	0	1877	5316	2326	551	154	312	108	99	22	138	79
	1993	20	602	1564	2077	1538	674	263	407	190	73	20	551
	1994	0	3258	2129	1847	2423	1948	952	173	828	502	100	951
	1995	3	159	657	527	763	583	641	297	110	145	200	201
	1996	0	2713	8447	5536	1897	1077	1281	632	209	37	121	206
	1997	0	838	10705	10633	6894	2935	1197	1868	1038	464	0	760
	1998	0	1892	2013	3876	1400	913	387	258	317	259	147	120
	1999	0	1370	1973	2623	4378	2284	1100	561	546	803	240	414
	2000	0	565	2667	2615	3018	2595	676	901	231	518	473	856
	2001	0	407	1661	5275	3258	2285	1884	1467	857	296	294	702
	2002	5	1409	2492	2340	2215	1101	746	804	603	359	95	517
	2003	0	1078	6629	3718	3222	2477	1197	593	860	454	377	555
	2004	0	229	1631	1795	1044	702	774	344	138	260	136	160
	2005	1	63	859	409	395	230	127	149	56	53	44	77
	2006	0	215	1648	2016	1125	1112	825	551	615	131	122	415
Trip Ticket SW FL	1981	0	0	370	2602	10938	1276	320	833	9	0	0	160
	1982	9	29	2	298	1030	1604	811	48	148	65	0	6
	1983	0	182	0	4010	1746	138	165	27	26	69	12	27
	1984	0	0	407	99	1865	1499	1199	516	77	22	18	142
	1985	0	0	20	19	63	225	599	127	89	11	5	9
	1986	0	2	65	366	571	677	389	11	20	10	0	1
	1987	0	464	192	1101	515	658	572	166	13	3	1	0
	1988	0	25	51	453	12161	29305	6334	1237	660	105	56	106
	1989	0	665	873	4373	4740	2232	2925	481	535	7	2	457
	1990	0	6	1127	2835	13208	1101	2275	398	160	92	11	181
	1991	6	1906	7589	4719	2559	2267	1425	451	92	1143	198	336
	1992	0	1160	16981	18403	6401	1822	4160	1180	1458	328	1393	576
	1993	16	2237	14806	22618	21131	9836	3168	4941	2173	863	257	4464

	1994	0	3077	6658	8828	9549	4824	1753	237	1510	571	174	482
	1995	12	1963	6322	3322	2747	1526	1166	548	207	275	300	369
	1996	0	3368	21791	15072	4352	1866	2103	1136	297	57	224	273
	1997	0	1267	10779	7950	4252	1514	646	881	513	241	0	292
	1998	0	2038	4657	11966	4048	2628	974	670	772	676	277	150
	1999	0	1407	1940	2714	5030	2909	1268	646	547	925	175	375
	2000	0	1748	4593	3253	3115	1730	457	541	173	147	211	251
	2001	0	290	1738	6049	3466	2365	1790	1319	749	257	220	680
	2002	2	1055	2371	2439	2371	1152	724	823	553	273	101	420
	2003	0	429	2812	2148	2077	1887	937	476	697	342	295	321
	2004	0	356	2381	2419	1374	844	942	383	152	323	165	235
	2005	3	313	5342	2968	3130	1782	964	1266	431	319	269	539
	2006	0	213	3014	4144	2203	2063	1188	690	628	144	122	346
MRFSS	1981	0	8623	2211	6838	44603	7296	1982	1424	584	1213	43	284
	1982	41	2294	20672	44436	31640	12769	2357	1484	4	80	111	425
	1983	0	2219	82468	100999	6956	6849	3663	199	274	529	149	8383
	1984	0	30387	4494	24101	141601	22996	5127	3984	2868	1475	7	1258
	1985	0	6153	19907	23383	5060	5165	5718	2291	451	75	0	1096
	1986	4670	12061	51201	75893	12154	9769	9972	4413	372	578	14	512
	1987	1339	19962	71807	84928	21441	21361	9994	3079	924	2312	148	859
	1988	422	19082	38221	45590	118102	88705	22104	35034	14582	1169	744	11521
	1989	765	87243	62816	83944	22880	24958	2948	2673	1562	2000	1152	1596
	1990	5919	22488	59062	84579	60817	13139	4140	4002	4925	1309	176	3741
	1991	1415	153585	210256	67036	30427	19056	10798	4773	1764	8468	3103	5631
	1992	0	77546	87206	64923	32094	13104	13285	10537	4266	4007	8321	6505
	1993	1096	52310	51501	62159	48707	25110	8305	12640	6219	2206	576	11463
	1994	0	72254	54448	40880	49435	47554	17565	4654	15592	7245	3245	8509
	1995	1295	18721	43534	27129	26099	20461	20740	12250	4656	3790	6134	6440
	1996	0	30563	105718	66425	32468	22418	21641	16182	14459	5076	1670	13578
	1997	0	18947	100273	91067	51424	24988	11357	13689	10869	6236	1371	7009
	1998	0	35567	42376	81138	50525	31894	15436	8865	10446	8389	4124	3828
	1999	0	53521	49707	38955	50571	27447	10690	6721	4937	8464	2877	5020
	2000	0	29534	82346	58036	41257	25032	7707	9028	2310	4108	2958	5435
	2001	21	19036	40730	69521	29814	17230	13387	10929	8148	3821	1908	7863
	2002	113	46303	118677	62311	46236	25572	15296	13058	11881	7017	3404	8816
	2003	0	13329	65961	42314	35425	26930	14562	6858	8048	5291	4316	4803
	2004	3	14087	79330	40854	26550	17307	17158	10300	4174	6655	3630	5915
	2005	41	5855	63056	31409	25812	18018	12246	11468	7601	3658	2724	9059
	2006	0	13557	106707	95895	55443	41254	24629	17746	15393	6820	3184	11561

Texas Parks and Wildlife Dept.	1981	0	0	25451	96	9914	12173	6563	4479	547	162	1	1783
	1982	0	66	1186	897	8058	15590	5810	6758	2631	1	1199	1389
	1983	0	1456	184	1795	6448	11004	7700	9363	3335	629	2524	619
	1984	0	114	32	963	4520	7174	3764	2109	656	776	128	433
	1985	0	278	141	554	2587	8352	3606	6639	479	727	948	1049
	1986	0	20	68	878	2466	5816	4433	2516	1485	603	1141	385
	1987	0	417	254	870	7993	6149	7742	576	1699	805	817	160
	1988	0	611	61	1116	5107	6825	3320	2439	1068	525	134	389
	1989	8	15	418	733	2533	6414	2272	3213	1111	679	411	873
	1990	27	78	42	1699	5014	5032	4718	3833	187	1188	491	478
	1991	0	4368	648	1354	14653	18119	1989	6126	379	629	0	322
	1992	0	570	2338	3175	3713	16722	635	3226	169	1	1078	262
	1993	0	18524	264	718	14354	16667	9787	5062	3820	242	90	2200
	1994	1	69	317	647	4638	1708	2925	874	24	605	44	299
	1995	8	807	4020	3596	3240	2275	2255	1081	410	372	445	463
	1996	0	729	4175	4308	2628	1800	1602	1255	647	170	134	519
	1997	0	420	5271	11478	8383	5320	2657	2896	2685	1685	465	1629
	1998	0	604	3622	13376	8291	6512	3405	2240	2557	2178	956	680
	1999	0	637	1985	4550	9357	6503	2819	1892	1255	2294	555	976
	2000	0	931	3619	4914	6699	7329	2764	2159	852	1916	1238	1838
	2001	1	399	1471	3789	3081	2067	1673	1618	1006	501	313	1162
	2002	3	549	1512	2637	5200	6530	2434	2594	1217	565	428	1068
	2003	0	310	1986	2581	4088	5350	2415	1191	1214	661	612	908
	2004	0	611	4170	5372	3904	3700	3828	1392	628	1183	432	703
	2005	6	124	3054	2877	8203	7689	1987	3247	401	548	285	590
	2006	0	312	3525	5545	3324	16363	4237	1383	1425	861	438	1098
Headboat	1981	0	881	697	563	653	685	57	71	79	19	0	75
	1982	0	881	697	563	653	685	57	71	79	19	0	75
	1983	0	881	697	563	653	685	57	71	79	19	0	75
	1984	0	881	697	563	653	685	57	71	79	19	0	75
	1985	0	881	697	563	653	685	57	71	79	19	0	75
	1986	0	6478	17116	5713	1942	2497	690	628	201	33	10	82
	1987	0	20	532	2584	350	584	162	22	39	178	1	7
	1988	35	810	829	742	872	617	151	239	26	20	14	86
	1989	0	3767	6764	6561	437	693	442	51	46	35	5	39
	1990	1654	36	2820	7022	5546	417	156	27	200	522	0	104
	1991	32	3324	7372	2991	1115	592	418	152	65	181	79	117
	1992	0	2672	2853	5491	4483	183	627	529	1100	16	177	44
	1993	74	3473	2916	6115	3783	1277	502	300	144	39	17	281
	1994	0	909	2411	5473	4026	1229	708	108	257	175	36	146

	1995	11	1425	4525	2843	1053	433	419	145	53	53	40	30
	1996	0	1632	9658	5839	2656	1243	1102	800	604	269	64	276
	1997	0	5827	8174	3978	1210	409	156	143	100	61	32	37
	1998	0	2942	1778	2214	1343	609	225	102	99	97	20	11
	1999	0	3108	3807	2083	1852	929	294	248	113	128	168	176
	2000	0	1434	3110	2292	1068	588	223	229	76	62	42	72
	2001	0	334	838	1361	785	419	301	276	232	116	36	174
	2002	2	937	2076	788	520	309	147	123	107	63	38	59
	2003	0	522	2778	1297	703	377	249	94	56	63	30	38
	2004	8	924	6859	1861	1280	687	479	357	138	246	160	282
	2005	56	973	9614	3271	1364	880	373	287	222	67	70	225
	2006	0	143	4648	4044	2801	1073	473	370	185	211	49	181
Charter Boat NW FL	1981	0	0	0	0	0	0	0	0	0	0	0	0
	1982	0	0	0	0	0	0	0	0	0	0	0	0
	1983	0	0	0	0	0	0	0	0	0	0	0	0
	1984	0	0	0	0	0	0	0	0	0	0	0	0
	1985	0	0	0	0	0	0	0	0	0	0	0	0
	1986	89	1084	11365	10615	730	553	1432	222	39	29	3	47
	1987	2	4739	16825	16797	2260	2645	1109	478	93	206	24	119
	1988	54	2063	5243	8225	24431	13558	3647	7300	3599	335	438	2736
	1989	190	14842	10700	9568	3449	3829	263	641	308	199	271	379
	1990	15	6705	20301	13400	4836	3219	1071	950	671	473	93	487
	1991	268	29232	37528	11014	4793	2903	1381	548	167	1281	221	679
	1992	65	5864	24326	14595	5094	1473	1414	807	373	88	428	475
	1993	208	12439	11110	10395	7015	2918	1123	1210	737	360	100	1581
	1994	50	28027	19716	9313	9945	6541	3168	960	2433	1211	624	1797
	1995	733	15045	39300	25016	8208	3164	3295	1805	733	408	793	1057
	1996	0	15941	49029	30406	12098	7525	8648	5558	3302	699	688	3199
	1997	0	5227	29699	23264	12100	5012	2138	2935	2128	1121	220	1419
	1998	0	15683	15526	31692	13882	8643	3763	2046	3005	2357	1060	1260
	1999	0	17861	11670	24317	31158	11503	7642	3273	1806	3111	638	1222
	2000	17456	10705	32859	23381	23346	12110	3390	3324	1303	1792	1296	1959
	2001	6	10836	23638	35528	15307	8129	5801	4298	2731	1000	718	2757
	2002	37	11688	16960	20180	23656	8238	7455	3913	2851	1670	1002	2992
	2003	0	2686	11009	9190	17243	8686	4136	2883	2009	1319	931	1460
	2004	11877	3897	16152	14438	11210	6273	5821	2584	1258	1863	838	889
	2005	8498	1674	9821	7270	21933	5418	4141	1923	2911	738	1217	1046
	2006	0	10799	29588	39771	44565	19414	12663	5755	5536	1129	1212	3893
Charter Boat SW FL	1981	0	0	0	0	0	0	0	0	0	0	0	0
	1982	0	0	0	0	0	0	0	0	0	0	0	0
	1983	0	0	0	0	0	0	0	0	0	0	0	0

	1984	0	0	0	0	0	0	0	0	0	0	0	0
	1985	0	427	56	95	108	180	25	8	0	0	7	3
	1986	0	471	1809	3614	1715	1564	559	489	89	59	34	121
	1987	0	8	207	1382	286	646	437	0	0	0	0	0
	1988	6	75	127	113	100	37	8	45	12	9	8	15
	1989	0	3433	7659	5701	1846	1719	255	81	196	206	23	117
	1990	1546	3068	2494	3374	3829	2513	2417	1082	3572	819	18	1963
	1991	0	774	3539	3405	1705	519	1114	483	331	111	438	389
	1992	3	1485	11268	17967	21459	12902	13219	3943	1967	12101	3535	8149
	1993	4	3575	25156	18643	27547	30761	11256	15301	3841	741	234	4159
	1994	117	22064	11215	20262	34738	95033	18990	14273	23175	9933	4121	11295
	1995	167	11015	61577	47978	29704	26536	28509	18860	9393	2109	4043	10347
	1996	0	5791	36836	28302	23136	15191	8945	11102	17574	7763	234	16618
	1997	0	8963	36945	76944	38740	26443	12342	10134	9774	7508	3580	4055
	1998	0	5028	14690	23208	25555	15034	7333	3844	4153	4714	1776	2092
	1999	0	6850	11548	10666	12837	8826	2756	2717	1171	2371	1426	2069
	2000	955	5840	15297	21205	16175	11704	9041	8077	3148	3793	1837	6650
	2001	4	7510	19610	25843	20405	11109	8912	9404	8367	4083	1207	6439
	2002	2	5831	27049	16842	11310	7073	3438	2043	1957	1186	1062	1948
	2003	0	2586	13567	13033	11604	5412	6583	2363	1424	2052	1849	2365
	2004	5770	2221	19534	9621	7038	4469	3680	2638	1140	1307	711	1625
	2005	3054	1407	14664	15661	10916	10768	7374	6417	5659	1596	1428	8607
	2006	0	1280	13637	16031	14807	5663	2804	2265	1319	1759	256	1597

3.1.1.3. Model Configuration and Equations

Virtual population analysis (VPA) is based on a family of techniques described by Murphy (1965) and Gulland (1965). The method assumes that the catch history of any given year-class is known without error, permitting the historical abundance and fishing mortality rates to be computed deterministically from an initial estimate of the abundance or fishing mortality rate on the oldest (terminal) age of the year class. The VPA can be “tuned” to ancillary information such as indices of abundance or tagging data (Doubleday, 1981; Parrack, 1986; Gavaris, 1989). For king mackerel, VPAs have been used since the mid-1980s (Nichols, 1985; Restrepo, 2008).

In recent years, and up to SEDAR5, the VPA program known as FADAPT (Restrepo, 1996) was used for king mackerel assessments. In 2008 the program VPA-2BOX (Porch et al., 1995) is being used instead because it offers more modeling options than does FADAPT, such as the ability to impose certain constraints on the solution, and the ability to model two stocks simultaneously with mixing between them. For simple applications, both FADAPT and VPA-

2BOX give the same results[2]. Like FADAPT, VPA-2BOX is based on the ADAPT model framework (Gavaris, 1989). Various implementations of ADAPT and VPA have been widely used for domestic fisheries in the United States, South Africa and Canada; as well as in several international arenas, including the International Commission of the Conservation of Atlantic Tuna (ICCAT) and the Northwest Atlantic Fisheries Organization (NAFO).

VPA-2BOX uses backwards recursion to fit age-structured models for one or two intermixing populations to catch, effort and abundance data. The basic methods are as follows (**Table 3.9**).

Table 3.9. Overlap and diffusion model equations describing population dynamics (stock: s, age: a, year:y, zone: j or k, A: age of plus-group, Y: most recent year in analysis).

Equations and variables	Description
$C_{kay} = \tilde{N}_{kay}\dfrac{F_{kay}\left(1-e^{-Z_{kay}}\right)}{Z_{kay}}$	Catch at age *a* in year *y* from all stocks in management zone *k*
$Z_{kay} = F_{kay} + M_{kay}$	Total mortality rate in zone *k*
F_{kay}	Fishing mortality rate in zone *k*
M_{kay}	Natural mortality rate in zone *k*
Overlap model	
$N_{s,a+1,y+1} = N_{say}\sum_{k} T_{skay}\, e^{-Z_{kay}}$	Number of fish from stock *s* that are age *a*+1 at the beginning of year *y* (*a*+1<*A*)
$N_{s,A,y+1} = \sum_{a=A-1}^{A} N_{say} \sum_{k} T_{skay}\, e^{-Z_{kay}}$	Number of fish from stock *s* that are age *A* or older at the beginning of year *y*
$\tilde{N}_{kay} = \sum_{s} T_{skay} N_{say}$	Number of fish in zone *k* that are age *a* at the beginning of year *y* (all stocks combined)
T_{skay}	Fraction of stock *s* residing in zone *k* at the beginning of year *y*
Diffusion model	
$\tilde{N}_{k,a+1,y+1} = \sum_{j} \tilde{N}_{jay}\tilde{T}_{jkay}\, e^{-Z_{kay}}$	Number of fish in zone *k* that are age *a*+1 at the beginning of year *y* (*a*+1<*A*)
$\tilde{N}_{k,A,y+1} = \sum_{a=A-1}^{A} \sum_{j} \tilde{N}_{jay}\tilde{T}_{jkay}\, e^{-Z_{kay}}$	Number of fish in zone *k* that are age *A* or older at the beginning of year *y*
$\tilde{T}_{kjay}$	Fraction of population in zone *j* that moves to zone *k* at the beginning of year *y*

[2] When the base case assessment for Gulf of Mexico king mackerel from SEDAR5 was implemented using VPA-2BOX, it gave the same results as FADAPT did in 2004 (S. Cass-Calay, pers. comm.)

Note that while mixing between two stocks is possible within the VPA-2BOX model framework, the models discussed in this paper do not allow mixing between the Gulf and Atlantic migratory groups. Instead, each migratory group is modeled as a separate stock in a single zone.

The catch equations (**Table 3.9**) contain many variables (N, F, M and T), yet only the catches are actually observed. VPA-2BOX overcomes this problem by using a backwards recursion to determine the historical abundance and fishing mortality rate of each cohort from the observed catches and prescribed values for natural mortality and the fishing mortality rate on the last age observed for the cohort (F_{Ay} or F_{aY}*)*. The challenge that remains is to choose appropriate values for M, F_{aY} and F_{Ay}. The method used for the SEDAR 16 VPA runs was to estimate these values by maximizing the model fits to indices of abundance by maximizing the log-likelihood function described in **Table 3.10**.

Table 3.10. Model for indices of abundance (index series: *i*, zone: *k*, age: *a*, year: *y*).

$\mathcal{L}(\vec{I}) = -\sum_i \sum_k \sum_y 0.5\left(\frac{\ln\left(I_{iky}/\hat{I}_{iky}\right)}{\sigma_{iky}}\right)^2 - \ln \sigma_{iky}$	log-likelihood term for lognormally distributed indices of abundance
$\hat{I}_{iky} = q_{iky}\sum_a s_{ika}\, w_{ikay}\, \widetilde{N}_{kay}$	predicted value of index
$s_{ika} = \frac{\sum_y C_{ikay} F_{kay}/C_{kay}}{\underset{a}{\mathrm{MAX}}\left\{\sum_y C_{ikay} F_{kay}/C_{kay}\right\}}$	availability at age (see Butterworth and Geromont, 1999)
I_{iky}	observed value of index
σ_{iky}	standard error of index on log scale
q_{ikay}	catchability coefficient
w_{ikay}	adjustment for weight and time of year (if needed)
C_{ikay}	catch associated with index *i* in zone *k*

This introduces several new variables that need to be accounted for—the index standard error σ, catchability *q*, and relative selectivity *S*. The values for σ were estimated internally using a concentrated maximum likelihood procedure. The values of *q* were assumed to be constant through time and estimated along with the other parameters. For the “Continuity Cases”, the values of *S* were determined from the partial catches corresponding to each index using the method of Powers and Restrepo (1992). “Partial catch” is generally defined as catch-at-age pertaining to survey area or fleet, relative to the total catch at age for all fleets combined.

3.1.1.4. Parameters Estimated

The estimated parameters were the terminal year (2006) fishing mortality rates for each age (Terminal F's). Like the SEDAR5 and MSAP 2003 assessments, the terminal Fs for age-1 (Atlantic) or ages 0 and 1 (Gulf) were fixed relative to the estimated terminal year F at age-2 using ratios derived from a separable VPA that used the most recent seven years of data (2000-2006). For the Atlantic assessment, the Terminal Fs for ages 3 -9 were estimated, and ages 10 and 11+ were assumed to have the same terminal F as age-9. For the Gulf assessment, the Terminal Fs for ages 3 -10 were estimated, and age-11+ was assumed to have the same terminal F as age-10. These assumptions are summarized in **Table 3.11**.

Table 3.11. Terminal F settings and initial guesses used for VPA "Continuity Cases".

	Atlantic		Gulf	
	Initial Value	Fixed or Estimated?	Initial Value	Fixed or Estimated?
Age 0	NA	NA	-	Fixed at 208.4% of Terminal F at Age-2
Age 1	-	Fixed at 9.62% of Terminal F at Age-2	-	Fixed at 17.7% Terminal F at Age-2
Age 2	0.067	Estimated	0.0351	Estimated
Age 3	0.213	Estimated	0.052	Estimated
Age 4	0.083	Estimated	0.4275	Estimated
Age 5	0.272	Estimated	0.3223	Estimated
Age 6	0.052	Estimated	0.1982	Estimated
Age 7	0.036	Estimated	0.0481	Estimated
Age 8	0.228	Estimated	0.2169	Estimated
Age 9	0.032	Estimated	0.3907	Estimated
Age 10	-	Fixed equal to Terminal F at Age-9	0.3397	Estimated
Age 11+	-	Fixed equal to Terminal F at Age-9	-	Fixed equal to Terminal F at Age-10

3.1.1.5. Uncertainty and Measures of Precision

It is possible to evaluate uncertainty using bootstrap runs of the index residuals. However, since the "Continuity Cases" were not constructed to provide management advice, no bootstrap runs were completed.

3.1.1.6. Methods Used to Compute Benchmark / Reference Points

Benchmarks are reference points were calculated using the current management criteria[3] (**Table 3.12**). The following treatments of the data and assumptions have been used:

Terminal F ($F_{Current}$): $F_{Current}$ was estimated as the apical F for the terminal year..

Current Selectivity: selectivity was computed from the geometric means of the age-specific fishing mortality values in the last five years of the VPA.

SSB: SSB is computed as the product of numbers at age at the beginning of each year, times maturity, times fecundity.

Expected spawner-recruit relationship: A two-line model. Maximum recruitment is given by the mean of the estimated recruitments for 1989-2004. The SSB at which recruitment starts to decline to the origin is given by the mean of the five lowest SSB estimates.

Table 3.12. Management criteria for the Gulf and South Atlantic regions, continuity case.

Criteria	Current Definition	
	South Atlantic	Gulf of Mexico
MSST	0.85(Bmsy)	0.8(Bmsy)
MFMT	Fmsy = F30%SPR	Fmsy = F30%SPR
MSY		Yield @30%SPR
F_{MSY}	Fmsy = F30%SPR	Fmsy = F30%SPR
OY	Yield @ F40% SPR	Yield @ 0.85Fmsy
F_{OY}	F40% SPR	0.85Fmsy
M	0.15	0.20

3.1.1.7. Projection methods

The "Continuity Cases" were not constructed to provide management advice. Therefore, no projections were attempted.

3.1.2. Model 1 Results

The purpose of the "Continuity Cases" was to demonstrate the effect of updating time series (catch and indices) without modifying modeling assumptions or life history functions (e.g. natural mortality, fecundity, growth etc). These models are not intended to be used for management advice. Therefore, a reduced set of results will be presented. The results are most properly compared to SEDAR 5 results prior to 2002.

[3] Julie Neer. SEDAR Coordinator. Provided to SEDAR16-AW 4/30/2008.

3.1.2.1. Measures of Overall Model Fit

The model fit was assessed using the objective function, likelihood statistics (**Table 3.13)** and the fits to the indices of abundance (**Figures 3.1 and 3.2**). AIC, AICC and BIC values are also summarized in **Table 3.13**, but these are not directly comparable across model with different numbers of parameters. The fits to the Atlantic indices of abundance were quite poor (indicated by lower log likelihoods). Some Gulf indices were fit quite well (i.e. HB, MRFSS and the SW FL Trip Ticket), but others were very poorly fit (i.e. Bycatch GLM and Charterboat SW).

Table 3.13 Likelihood Statistics for "Continuity" models.

Model	ATL-Continuity		GOM-Continuity	
Total objective function	-33.22		-43.37	
(with constants)	62.35		111.94	
Number of parameters	18		18	
Number of data points	104		169	
AIC	160.69		259.87	
AICC	168.74		264.43	
BIC	208.29		316.21	
Chi-square discrepancy	97.38		212.71	
Loglikelihoods (deviance)	33.22		43.37	
effort data	33.22		43.37	
Log-posteriors	0		0	
catchability	0		0	
f-ratio	0		0	
natural mortality	0		0	
mixing coeff.	0		0	
Constraints	0		0	
terminal F	0		0	
stock-rec./sex ratio	0		0	
Out of bounds penalty	0		0	
Log Likelihoood: Indices of Abundance	33.23		43.34	
Index 1	'NC_com_TT'	13.59	'FL_TT_NW'	6.91
Index 2	'FL_com_TT'	3.45	'FL_TT_SW'	8.27
Index 3	'MRFSS'	5.91	'MRFSS'	11.08
Index 4	'HeadB'	7.97	'TX_PWD'	2.88
Index 5	'SEAMAP'	2.31	'HeadBoat'	10.81
Index 6	NA		'Charter_FL_NW'	5.22
Index 7	NA		'Charter_FL_SW'	0.82
Index 8	NA		'Bycatch_GLM'	-4.11
Index 9	NA		'SEAMAP'	1.46

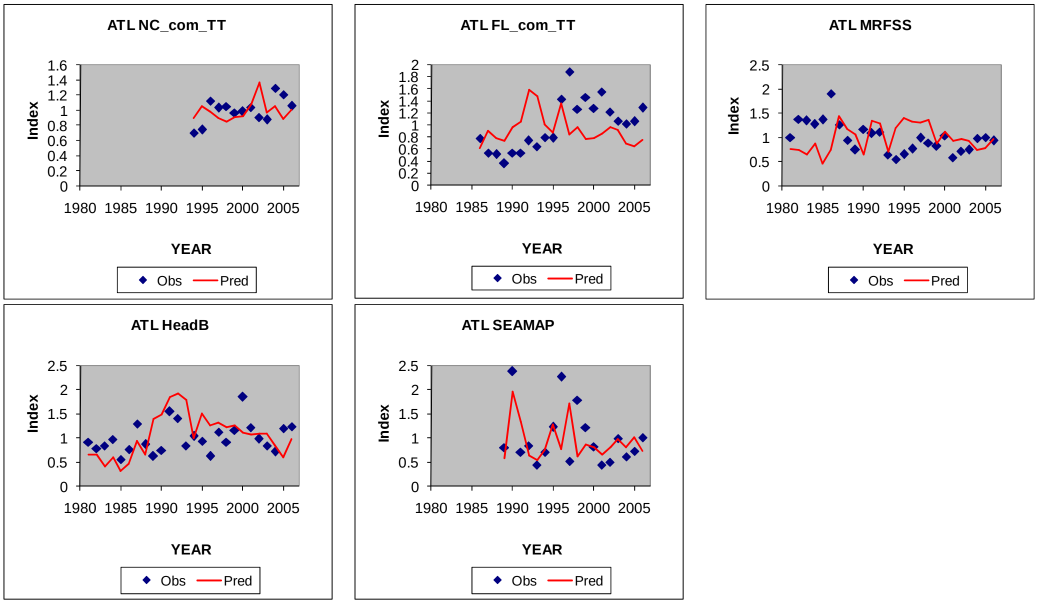


Figure 3.1. Fits to indices of abundance for the Atlantic “continuity case”.

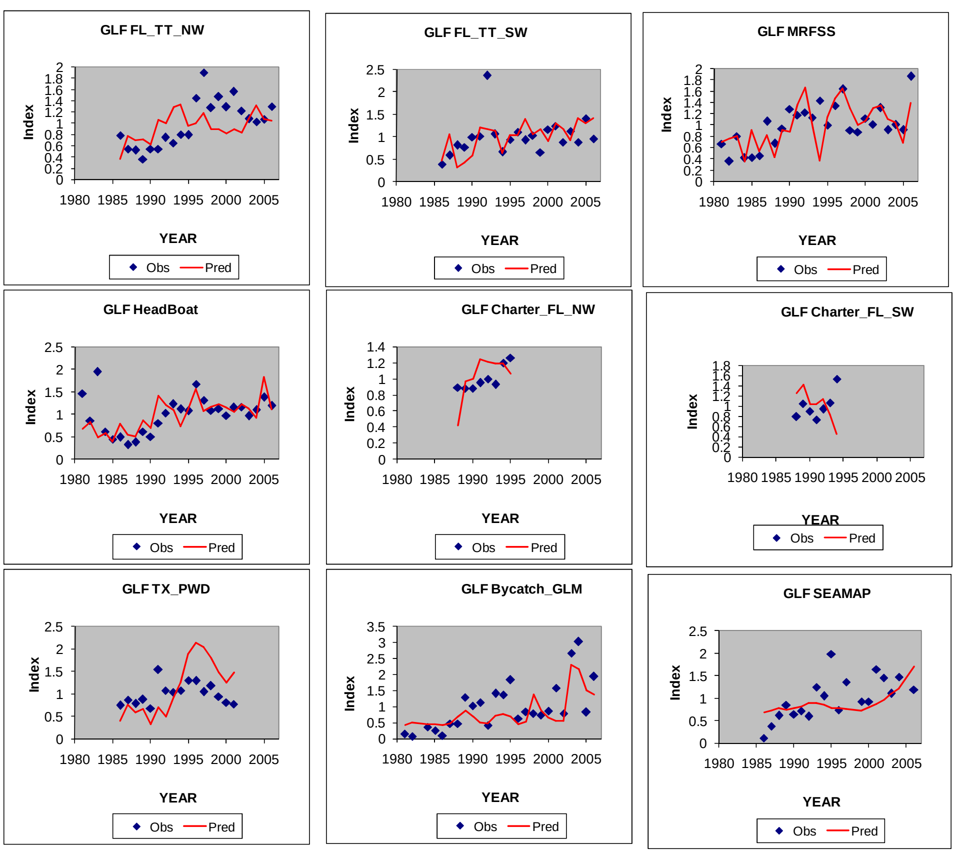


Figure 3.2. Fits to indices of abundance for the Gulf “continuity case”.

3.1.2.2. Parameter estimates & associated measures of uncertainty

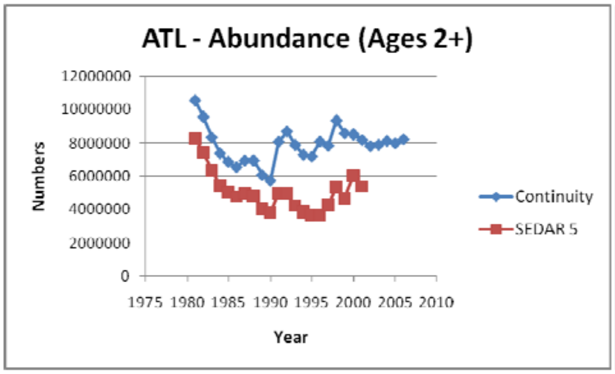
The Terminal Year F parameter estimates for the Atlantic and Gulf "continuity cases" are summarized in **Table 3.14.** Fixed values are indicated with gray shading. No measures of uncertainty are available because no bootstraps were completed for the continuity cases.

Table 3.14. Final terminal year F estimates for the continuity cases. Fixed values are shaded.

Terminal Year F	Atlantic	Gulf
Age 0	Not Used	2.084
Age 1	0.096	0.177
Age 2	0.066	0.031
Age 3	0.215	0.046
Age 4	0.083	0.426
Age 5	0.274	0.337
Age 6	0.053	0.208
Age 7	0.036	0.077
Age 8	0.229	0.040
Age 9	0.032	0.400
Age 10	0.032	0.362
Age 11	0.032	0.362

3.1.2.3. Stock Abundance and Recruitment

Annual estimates of the size of the adult stock (Age 2+) are summarized in **Figure 3.3.** The continuity run suggests a larger adult population in the Atlantic, relative to the SEDAR 5 results. The Gulf estimates are comparable throughout the time-series.



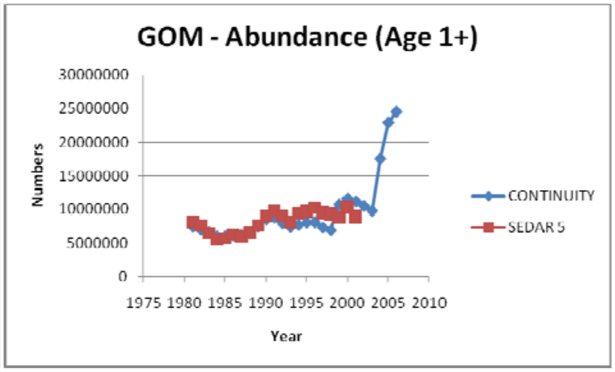


Figure 3.3. Comparison of annual abundance estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run.

For SEDAR 5 and VPA continuity runs, the Atlantic models began at Age 1. The estimates of recruitment at age-1 from SEDAR 5 and the continuity run are similar in magnitude (averaging 2 million) until 1997, then the continuity estimates are substantially higher than the SEDAR 5 estimates (**Figure 3.4**). In the Gulf, the recruitment estimates are roughly equal in magnitude (averaging 3.5 million) during 1981-2001, and vary largely without trend until the recent years. However, some differences are notable after 1997. Gulf recruitment estimates are markedly higher between after 2003, 10.5 million on average.

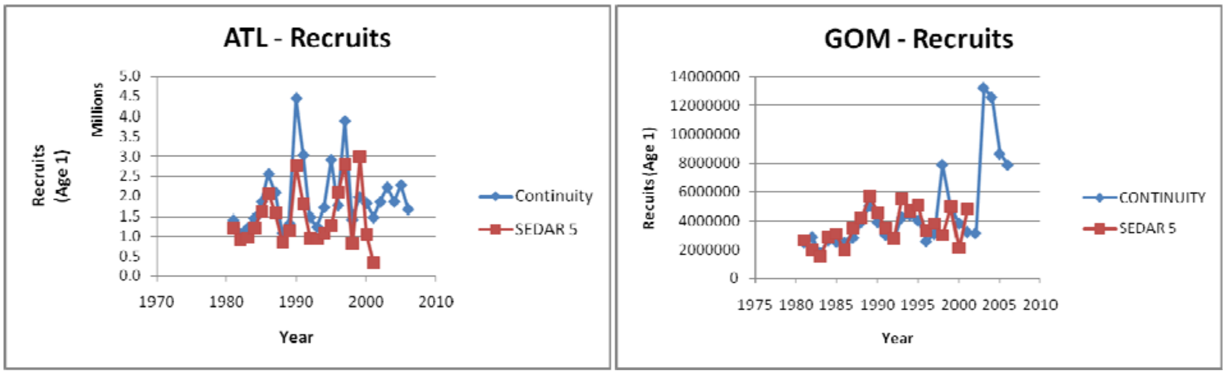


Figure 3.4. Comparison of annual recruitment estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run.

3.1.2.4. Stock Biomass (total and spawning stock)

The spawning stock biomass estimates for the Atlantic and Gulf continuity cases are summarized in **Figure 3.5**. During the initial years of the time series, the Atlantic spawning stock biomass was estimated to be larger than that in the Gulf. However, in the most recent years, the Gulf stock biomass increased steeply, and in 2005 and 2006, the Gulf spawning stock biomass exceeded that in the Atlantic.

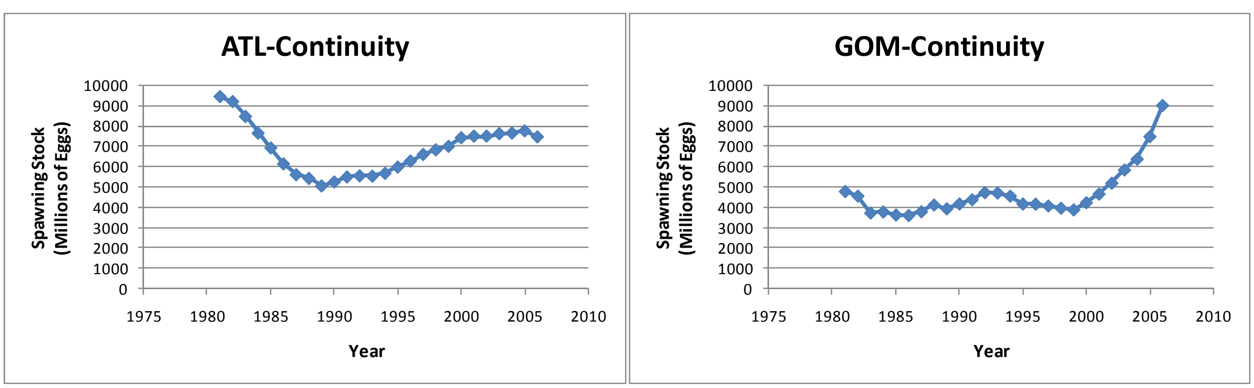


Figure 3.5. Spawning stock trajectories from the VPA continuity cases.

3.1.2.5. Fishery Selectivity

Fishery selectivity was estimated using the partial catches (fleet or index specific catches-at-age) using the Powers and Restrepo (1992) method which allows selectivity to vary by year, and requires the partial catches –at-age to be fit exactly. This is the same method used during previous assessments of king mackerel. For the Atlantic model, one exception was the SEAMAP trawl selectivity which was fixed at 1.0 for Age 1 and 0.0 for all other ages. The fishery selectivity estimates for the other Atlantic fleets/indices are summarized in **Table 3.15**.

Table 3.15. Fishery selectivity-at-age for the Atlantic continuity case.

NC_com_TT

Selectivities by age

Year	2	3	4	5	6	7	8	9	10	11
1994	0.250	0.146	0.147	0.202	0.786	1.000	0.349	0.720	0.724	0.781
1995	0.181	0.445	0.367	0.255	0.397	1.000	0.869	0.571	0.699	0.569
1996	0.105	0.348	1.000	0.787	0.279	0.345	0.586	0.639	0.504	0.186
1997	0.413	0.258	0.490	0.634	0.345	0.220	0.257	1.000	0.423	0.330
1998	0.111	0.705	0.310	0.558	1.000	0.245	0.184	0.179	0.137	0.191
1999	0.359	0.226	1.000	0.331	0.572	0.488	0.351	0.191	0.109	0.143
2000	0.278	0.366	0.311	1.000	0.274	0.269	0.504	0.304	0.173	0.210
2001	0.147	0.401	0.411	0.265	1.000	0.315	0.515	0.647	0.254	0.388
2002	0.343	0.427	1.000	0.690	0.454	0.851	0.370	0.684	0.218	0.277
2003	0.484	0.299	0.397	1.000	0.472	0.261	0.769	0.157	0.077	0.130
2004	0.513	0.858	0.514	0.581	1.000	0.152	0.230	0.187	0.024	0.083
2005	0.038	0.134	0.632	0.769	0.662	0.027	1.000	0.079	0.361	0.217
2006	0.292	0.791	0.295	1.000	0.401	0.176	0.710	0.153	0.128	0.193

FL_com_TT

Selectivities by age

Year	2	3	4	5	6	7	8
1986	0.014	0.045	0.162	0.461	0.802	0.339	1.000
1987	0.254	0.370	0.659	0.993	1.000	0.362	0.417
1988	0.374	0.506	0.505	0.246	0.556	1.000	0.479
1989	0.288	0.393	0.384	0.495	0.663	0.612	1.000
1990	0.491	0.564	0.502	0.530	0.803	0.777	1.000
1991	0.250	0.589	0.419	0.664	0.679	0.665	1.000
1992	0.606	0.700	0.897	1.000	0.640	0.695	0.582
1993	0.568	0.618	0.542	0.806	1.000	0.725	0.926
1994	0.637	0.372	0.395	0.398	1.000	0.670	0.494
1995	0.218	0.391	0.378	0.298	0.431	0.959	1.000
1996	0.676	0.695	0.999	0.516	0.289	0.504	1.000
1997	1.000	0.304	0.414	0.476	0.210	0.195	0.183
1998	0.164	1.000	0.445	0.572	0.508	0.238	0.301
1999	0.279	0.207	1.000	0.315	0.407	0.393	0.301
2000	0.443	0.433	0.327	1.000	0.183	0.186	0.119
2001	0.172	0.641	0.738	0.339	1.000	0.119	0.155
2002	0.258	0.334	1.000	0.591	0.304	0.906	0.217
2003	0.418	0.260	0.399	1.000	0.510	0.265	0.918
2004	0.139	0.469	0.222	0.338	1.000	0.259	0.166
2005	0.031	0.036	0.395	0.857	0.382	0.374	1.000
2006	0.130	0.591	0.253	0.919	0.159	0.122	1.000

MRFSS

Selectivities by age

Year	2	3	4	5	6	7	8	9	10	11
1981	0.116	0.049	0.240	0.344	0.325	0.440	1.000	0.126	0.168	0.204
1982	0.023	0.017	0.131	0.283	0.521	1.000	0.692	0.547	0.342	0.256
1983	0.112	0.232	0.164	0.251	0.296	0.685	1.000	0.292	0.064	0.181
1984	0.028	0.066	0.314	0.254	1.000	0.754	0.890	0.423	0.487	0.447
1985	0.187	0.191	0.052	0.244	0.117	0.249	1.000	0.656	0.153	0.176
1986	0.182	0.312	0.757	0.655	0.467	0.184	1.000	0.721	0.217	0.302
1987	0.850	0.508	0.793	1.000	0.899	0.323	0.332	0.648	0.521	0.543
1988	0.502	0.605	0.545	0.260	0.497	1.000	0.420	0.494	0.802	0.840
1989	0.413	0.488	0.441	0.551	0.704	0.678	1.000	0.503	0.915	0.845
1990	0.366	0.357	0.314	0.290	0.374	0.309	0.402	1.000	0.464	0.500
1991	0.387	0.715	0.454	0.633	0.628	0.621	0.865	0.706	1.000	0.860
1992	0.344	0.469	0.599	0.644	0.462	0.537	0.361	0.595	0.975	1.000
1993	0.167	0.168	0.184	0.380	0.451	0.459	0.603	0.464	0.824	1.000
1994	0.834	0.337	0.362	0.372	1.000	0.700	0.560	0.767	0.705	0.782
1995	1.000	0.808	0.483	0.339	0.423	0.724	0.783	0.694	0.743	0.704
1996	0.413	0.652	0.991	0.560	0.313	0.452	1.000	0.929	0.456	0.568
1997	0.794	0.384	0.635	0.801	0.460	0.356	0.376	1.000	0.585	0.619
1998	0.255	1.000	0.488	0.682	0.647	0.369	0.388	0.435	0.523	0.543
1999	0.324	0.207	1.000	0.300	0.391	0.358	0.258	0.223	0.240	0.228
2000	0.703	0.513	0.326	1.000	0.198	0.213	0.202	0.199	0.279	0.260
2001	0.183	0.563	0.617	0.320	1.000	0.209	0.217	0.224	0.311	0.296
2002	0.325	0.352	1.000	0.577	0.292	0.851	0.206	0.163	0.164	0.152
2003	0.482	0.278	0.399	1.000	0.500	0.261	0.937	0.098	0.108	0.093
2004	0.166	0.535	0.238	0.344	1.000	0.316	0.188	0.667	0.104	0.089
2005	0.029	0.143	0.602	1.000	0.518	0.534	0.908	0.134	0.311	0.180
2006	0.268	0.845	0.317	1.000	0.143	0.117	0.755	0.093	0.099	0.101

HeadB

Selectivities by age

Year	1	2	3	4	5	6	7	8
1981	0.019	0.130	0.045	0.264	0.366	0.368	0.383	1.000
1982	0.029	0.055	0.039	0.307	0.315	0.726	0.654	1.000
1983	0.033	0.144	0.075	0.056	0.202	0.254	0.608	1.000
1984	0.020	0.048	0.115	0.225	0.262	0.600	1.000	0.646
1985	0.015	0.159	0.156	0.025	0.192	0.099	0.181	1.000
1986	0.009	0.049	0.134	0.316	0.383	0.576	0.428	1.000
1987	0.172	0.306	0.392	0.686	1.000	0.894	0.275	0.321
1988	0.033	0.282	0.372	0.419	0.234	0.528	1.000	0.415
1989	0.756	0.939	0.709	0.540	0.601	0.737	0.685	1.000
1990	0.154	1.000	0.895	0.804	0.724	0.896	0.729	0.877
1991	0.273	0.719	1.000	0.553	0.695	0.575	0.499	0.631
1992	0.296	0.669	0.739	0.916	1.000	0.628	0.691	0.525
1993	0.467	0.994	0.606	0.561	0.872	1.000	0.738	0.868
1994	0.294	1.000	0.351	0.299	0.251	0.538	0.316	0.232
1995	0.291	1.000	0.824	0.515	0.374	0.445	0.764	0.747
1996	0.101	0.464	0.720	1.000	0.582	0.287	0.413	0.902
1997	0.133	1.000	0.341	0.567	0.727	0.382	0.332	0.333
1998	0.253	0.327	1.000	0.418	0.538	0.463	0.228	0.283
1999	0.413	0.880	0.286	1.000	0.276	0.343	0.317	0.211
2000	0.011	0.941	0.596	0.334	1.000	0.169	0.168	0.127
2001	0.044	0.306	0.880	0.901	0.382	1.000	0.146	0.157
2002	0.256	0.473	0.370	1.000	0.546	0.277	0.770	0.181
2003	0.050	0.875	0.365	0.425	1.000	0.435	0.205	0.685
2004	0.106	0.306	0.629	0.249	0.347	1.000	0.269	0.172
2005	0.000	0.055	0.226	0.551	0.563	0.533	0.393	1.000
2006	0.016	0.325	1.000	0.331	0.996	0.095	0.080	0.566

The fishery selectivity estimates for the Gulf fleets/indices are summarized in **Table 3.16**. Two Gulf selectivity vectors were fixed, the SEAMAP Groundfish survey (fixed to 1.0 at Age-0 and 0.0 for other ages) and the SEAMAP Ichthyoplankton survey (SSB index-Selectivity fixed equal to Fecundity*Maturity-at-age)

Table 3.16. Fishery selectivity-at-age for the Gulf continuity case.

FL_TT_NW

Selectivities by age

Year	3	4	5	6
1986	1.000	0.025	0.087	0.800
1987	1.000	0.525	0.579	0.321
1988	0.626	0.784	1.000	0.151
1989	0.535	0.802	1.000	0.041
1990	1.000	0.481	0.211	0.417
1991	0.637	0.884	1.000	0.649
1992	1.000	0.354	0.270	0.804
1993	1.000	0.829	0.597	0.628
1994	0.799	1.000	0.929	0.712
1995	0.382	1.000	0.746	0.982
1996	1.000	0.678	0.711	0.772
1997	0.935	1.000	0.861	0.639
1998	1.000	0.509	0.529	0.463
1999	0.514	1.000	0.741	0.534
2000	0.463	0.982	1.000	0.343
2001	0.209	0.736	1.000	0.921
2002	0.297	0.215	0.740	1.000
2003	0.598	0.428	0.241	1.000
2004	1.000	0.733	0.385	0.297
2005	0.719	1.000	0.700	0.272
2006	0.121	0.683	1.000	0.794

FL_TT_SW

Selectivities by age

Year	3	4	5	6	7	8
1986	0.202	0.224	0.533	1.000	0.029	0.084
1987	0.696	0.627	0.524	0.962	1.000	0.071
1988	0.004	0.190	1.000	0.110	0.048	0.099
1989	0.194	0.300	0.279	1.000	0.056	0.154
1990	0.163	1.000	0.104	0.469	0.235	0.027
1991	0.549	0.797	1.000	0.671	0.495	0.298
1992	0.738	0.383	0.298	1.000	0.266	0.784
1993	0.552	0.577	0.441	0.384	1.000	0.326
1994	0.475	0.490	0.286	0.163	0.060	1.000
1995	0.669	1.000	0.542	0.496	0.332	0.352
1996	1.000	0.571	0.452	0.466	0.310	0.117
1997	1.000	0.882	0.635	0.493	0.587	0.430
1998	1.000	0.477	0.493	0.377	0.456	0.450
1999	0.463	1.000	0.822	0.535	0.580	0.852
2000	0.568	1.000	0.658	0.229	0.393	0.272
2001	0.231	0.756	1.000	0.845	0.782	0.659
2002	0.270	0.200	0.674	0.844	1.000	0.856

2003	0.299	0.239	0.159	0.677	0.708	1.000
2004	0.843	0.604	0.289	0.226	1.000	0.797
2005	0.555	0.842	0.576	0.220	0.196	1.000
2006	0.135	0.721	1.000	0.617	0.224	0.134

MRFSS

Selectivities by age

Year	2	3	4	5	6	7	8
1981	0.042	0.229	1.000	0.419	0.211	0.201	0.136
1982	0.234	0.733	1.000	0.356	0.168	0.158	0.001
1983	0.650	1.000	0.110	0.217	0.114	0.015	0.027
1984	0.012	0.096	1.000	0.232	0.096	0.071	0.126
1985	0.857	0.764	0.282	0.763	1.000	0.681	0.112
1986	0.346	1.000	0.114	0.184	0.614	0.281	0.038
1987	0.597	1.000	0.486	0.317	0.313	0.346	0.097
1988	0.083	0.142	0.611	1.000	0.126	0.448	0.725
1989	0.614	1.000	0.388	0.835	0.270	0.084	0.120
1990	0.288	1.000	0.945	0.253	0.175	0.485	0.169
1991	1.000	0.455	0.553	0.491	0.297	0.306	0.333
1992	1.000	0.815	0.601	0.671	0.999	0.744	0.718
1993	0.545	0.593	0.520	0.441	0.393	1.000	0.365
1994	0.168	0.213	0.246	0.273	0.158	0.114	1.000
1995	0.483	0.575	1.000	0.765	0.929	0.781	0.832
1996	0.739	0.773	0.747	0.952	0.841	0.775	1.000
1997	0.845	1.000	0.931	0.915	0.757	0.796	0.796
1998	0.496	1.000	0.878	0.883	0.881	0.891	0.897
1999	0.500	0.661	1.000	0.771	0.449	0.600	0.764
2000	0.231	0.765	1.000	0.718	0.291	0.495	0.275
2001	0.278	0.365	0.893	1.000	0.868	0.889	0.984
2002	0.819	0.374	0.212	0.813	0.970	0.862	1.000
2003	0.635	0.510	0.353	0.196	0.912	0.883	1.000
2004	0.748	0.530	0.434	0.221	0.153	1.000	0.813
2005	0.085	0.333	0.394	0.331	0.158	0.101	1.000
2006	0.151	0.156	0.908	1.000	0.640	0.288	0.164

TX_PWD

Selectivities by age

Year	2	3	4	5	6	7	8
1986	0.002	0.042	0.085	0.402	1.000	0.588	0.556
1987	0.009	0.042	0.749	0.376	1.000	0.267	0.739
1988	0.002	0.045	0.343	1.000	0.246	0.406	0.690
1989	0.019	0.041	0.200	1.000	0.970	0.468	0.399
1990	0.000	0.043	0.168	0.209	0.429	1.000	0.014
1991	0.007	0.020	0.571	1.000	0.117	0.842	0.154
1992	0.031	0.047	0.081	1.000	0.056	0.266	0.033
1993	0.006	0.015	0.331	0.631	1.000	0.864	0.484
1994	0.037	0.128	0.875	0.372	1.000	0.813	0.059
1995	0.359	0.614	1.000	0.685	0.814	0.556	0.590
1996	0.382	0.655	0.791	1.000	0.814	0.786	0.585
1997	0.226	0.641	0.772	0.990	0.900	0.856	1.000
1998	0.189	0.733	0.640	0.801	0.863	1.000	0.975
1999	0.103	0.397	0.952	0.940	0.609	0.869	1.000
2000	0.048	0.308	0.772	1.000	0.497	0.562	0.483
2001	0.076	0.151	0.701	0.911	0.823	1.000	0.922

HeadBoat

Selectivities by age

Year	2	3	4	5	6
1981	0.335	0.480	0.372	1.000	0.155
1982	0.382	0.450	1.000	0.925	0.198
1983	0.252	0.256	0.475	1.000	0.082
1984	0.266	0.324	0.667	1.000	0.155
1985	0.296	0.182	0.359	1.000	0.099
1986	1.000	0.651	0.158	0.407	0.368
1987	0.145	1.000	0.261	0.285	0.167
1988	0.259	0.331	0.648	1.000	0.124
1989	0.845	1.000	0.095	0.297	0.519
1990	0.160	0.964	1.000	0.093	0.077
1991	1.000	0.580	0.578	0.435	0.327
1992	0.390	0.821	1.000	0.112	0.562
1993	0.529	1.000	0.692	0.384	0.408
1994	0.261	1.000	0.702	0.248	0.224
1995	0.833	1.000	0.670	0.269	0.311
1996	0.994	1.000	0.900	0.777	0.630
1997	1.000	0.634	0.318	0.217	0.151
1998	0.763	1.000	0.856	0.618	0.471
1999	1.000	0.924	0.957	0.682	0.323
2000	0.289	1.000	0.857	0.558	0.279
2001	0.235	0.294	0.968	1.000	0.804
2002	1.000	0.331	0.166	0.686	0.650
2003	1.000	0.584	0.261	0.103	0.583
2004	1.000	0.373	0.323	0.135	0.066
2005	0.374	1.000	0.600	0.466	0.139
2006	0.144	0.143	1.000	0.567	0.268

Charter_FL_NW

Selectivities by age

Year	2	3	4	5	6
1988	0.074	0.167	0.826	1.000	0.136
1989	0.816	0.889	0.456	1.000	0.188
1990	0.625	1.000	0.474	0.392	0.286
1991	1.000	0.419	0.488	0.419	0.213
1992	1.000	0.657	0.342	0.271	0.381
1993	1.000	0.844	0.637	0.435	0.452
1994	1.000	0.797	0.812	0.617	0.469
1995	0.823	1.000	0.593	0.223	0.278

Charter_FL_SW

Selectivities by age

Year	3	4	5	6	7	8
1988	0.580	0.856	0.694	0.079	0.952	1.000
1989	1.000	0.461	0.847	0.344	0.037	0.223
1990	0.304	0.454	0.370	0.780	1.000	0.937
1991	0.370	0.496	0.213	0.489	0.495	1.000
1992	0.227	0.404	0.665	1.000	0.280	0.333
1993	0.147	0.243	0.446	0.441	1.000	0.186
1994	0.071	0.116	0.367	0.115	0.236	1.000

3.1.2.6. Fishing Mortality

Annual trends in fishing mortality are illustrated using apical F, which is defined as the maximum F-at-age in a given year. In the Atlantic, the SEDAR 5 and continuity run estimates are similar until 1991 and between 1999 and 2001 (**Figure 3.6**). During other years, the estimates diverge. The continuity run generally produced lower estimates of apical F. In the Gulf, the SEDAR 5 and continuity run estimates of apical F are similar until 1986 and between 1997 and 2001. The estimates produced by the continuity run are quite variable annually, and are often substantially larger than the estimates from SEDAR 5.

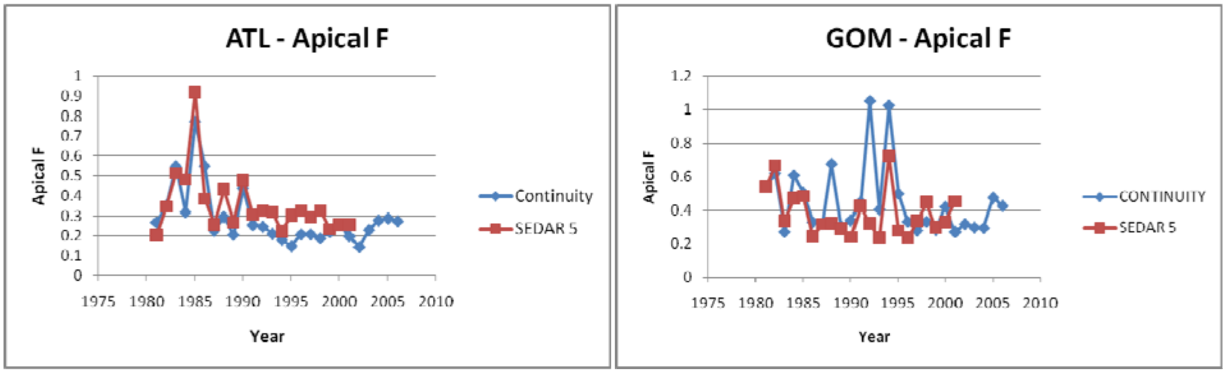


Figure 3.6. Comparison of annual fishing mortality estimates from the SEDAR 5 F-ADAPT model tand the VPA-2BOX continuity run.

3.1.2.7. Stock-Recruitment Parameters

There were no obvious spawner-recruit relationships for king mackerel in the Gulf or Atlantic (**Figure 3.7**), therefore it was necessary to assume a fixed S-R relationship for the calculation of management benchmarks and reference points. SEDAR 5 used a two-line (hockey-stick) S-R function constructed using data from years where recruitment and spawning stock were observed (for the continuity cases, Atl: 1989-2004 and Gulf: 1981-2004) By convention, the last two years were not used because they are estimated with high uncertainty by backwards recursive models such as VPA-2BOX. R_{MAX} was set equal to the average recruitment during the years included. The SSB hinge was fixed at the mean of the five lowest observed SSB estimates in the Gulf (As per SEDAR 5). However, in the Atlantic, it was not possible to fix the SSB hinge using the SEDAR 5 logic because the resulting estimate of F_{SPR30} (the proxy for F_{MSY}) was not estimable because it resulted in a replacement line (the inverse of the equilibrium SSB/R resulting from $F_{30\%}$) that did not intersect the expected stock-recruitment relationship. That is, $F_{30\%}$ would be unsustainable according to the two-line strock-recruitment relationship that was assumed. Therefore, for the sake of comparison with SEDAR5, a constant recruitment (equal to the mean of the included observation) was used instead. The values fixed values used for calculation of management benchmarks are summarized in **Table 3.17**.

Table 3.17. Stock recruitment parameters for the continuity cases.

Region	Type	R_{MAX} (Age-1)	SSB Hinge (millions of eggs)
ATL	Constant R	2.098E+06	0
GULF	Fixed at 0.95	4.336E+06	3693.2

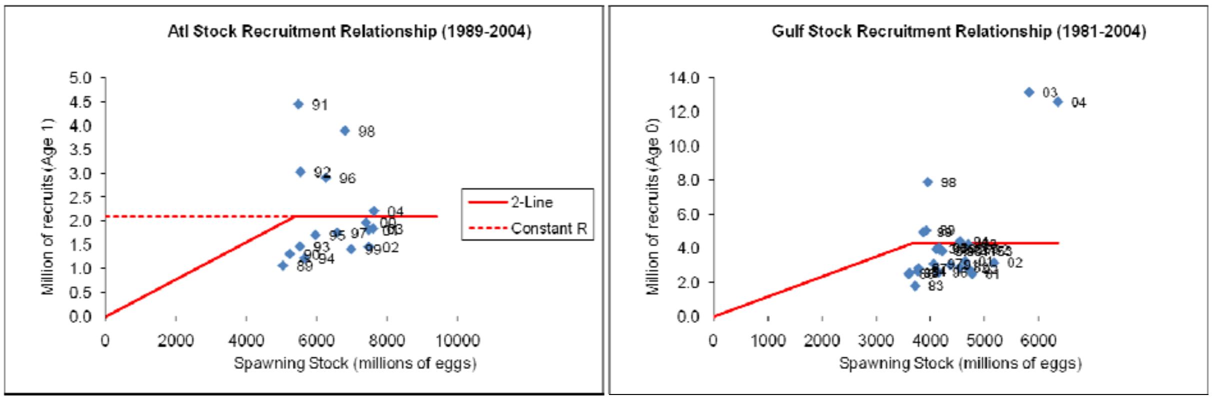


Figure 3.7. S-R functions fit to the results of the continuity cases. The solid line is the 2-line function fit to the data and used in the Gulf. The dashed line is the constant recruitment assumption used in the Atlantic.

3.1.2.8. Evaluation of Uncertainty

Because the continuity cases are intended to be used for management advice, no evaluations of uncertainty were completed.

3.1.2.9. Benchmarks / Reference Points / ABC values

Benchmarks and reference points are shown in **Table 3.18**.

Table 3.18. Management benchmarks and reference points for the continuity runs (See **Table 3.12** for an explanation of how different benchmarks were measured).

	South Atlantic	Gulf of Mexico
MSST	3833.54	6002.45
MFMT	0.35	0.29
MSY (lbs)	7.03E+06	1.27E+07
F_{MSY}	0.35	0.29
OY (lbs)	6.19E+06	1.08E+07

F_{OY}	0.21	0.25
F 2006	0.27	0.43
SSB 2006	7027.00	8976.00
F 2006 / MFMT	0.79	1.46
SSB 2006 / MSST	1.83	1.50

3.2. Model 2 Base VPA

3.2.1. Methods

3.2.1.1. Overview

The base VPA runs are intended to use all the data treatments and modeling choices agreed to by the SEDAR16 Assessment Workshop. The base runs differ from the "Continuity Cases" in that they: 1) use the "50/50 mixing zone assumption" (i.e., that 50% of the fish caught in the mixing zone during Winter belong to the Gulf group and 50% to the Atlantic group); 2) include Age-0 in the Atlantic models; 3) estimate certain terminal-F (fishing mortality) parameters that had previously been fixed; 4) include updated life history information and catch-at-age information developed for, and recommended by the SEDAR 16 data workshop panel; 5) use a different method to estimate index selectivity by age from partial catches (Butterworth and Geromont, 1999); and, 6) use a different weighting scheme for the indices. Like the "Continuity Cases", the "Base Runs" used the software program VPA-2BOX ver. 3.0.5.

VPA base runs were made with and without the application of a "recruitment patch" (replacing the 2005 and 2006 recruitments with values from the S-R relationship, and recalculating stocks sizes and F values for age 0 in 2005-2006 and age 2 in 2006 based on the input catch values). The SEDAR16-AW panel recommended the use of the recruitment patch, but we have preserved the base run using the original values for comparison, and for further consideration by the SEDAR16-RW panel.

3.2.1.2. Data Sources

The general model structure and settings are discussed in **Table 3.19**.

Table 3.19. Model settings and inputs used to construct the VPA "base runs".

Settings/Input Series	VPA-2BOX Base Runs

Stock Definitions	Catches and indices calculated according to the status quo mixing zone assumption: **ATL stock** - US Atlantic north of Volusia County, FL during Nov – Mar, and Monroe County FL and northward during Apr– Oct. **GOM stock** - US Gulf of Mexico from Texas to Collier County, FL during Apr - Oct and to Volusia County, FL during Nov- Mar.
Fishing Year	Like SEDAR5, catch and Indices estimated using "fishing year" definitions.
Directed Landings/Discards	Used updated SEDAR 16 landings estimates. For the recreational sector, used SEDAR 16 landings, discards and release mortality estimates. As per SEDAR 16 recommendation, commercial discards were assumed to be negligible.
Shrimp Bycatch	Used Delta Lognormal Shrimp Bycatch estimates (AW-xx-xx)
Catch-at-age	For estimation of the CAA: updated growth von Bertalanffy parameters (SEDAR16-DW-06) by sex and stock using observations collected outside of the MIX area. CAS 2001-2006 updated, sex at size ratios updated from 1985 through 2006. ALK constructed by semester and used from 1984 to 2006, SAR only for 1981-84 years. recreational CAA adjusted to meet SEDAR 16 recommendations.
Weight-at-Age	Updated vector of weight at age estimated from the age samples and the updated weight-at-size relationship by sex and stock from samples from non-mixing areas.
Indices of Abundance	Used indices consistent with the "updated" approached recommended by SEDAR 16 for SS3 and other updated model runs.
Natural Mortality	Used Lorenzen M vector developed at SEDAR16 DW and AW workshops.
Terminal Year F-at-age	Estimating all Terminal F's for ages 0-11+ (GOM) and 1-11+ (ATL) with fixed ratio for last age class all years of 1 and using maximum likelihood estimation with lognormal error distribution for index variances.
Annual F-Ratio	Like SEDAR5, for each year $F_{10} : F_{11+}$ was fixed at 1.0. This implies that the fishing mortality rate on the plus group is equal to the fishing mortality rate on age 10.

The maturity series used for the VPA "base runs" was unchanged from the values reported in **Table 3.2**. However, the SEDAR16 DW and AW working groups constructed a new natural mortality function (Lorenzen, 1996) that varied with age and an updated fecundity-at-age vector. These biological functions are summarized in **Table 3.20**. Also, revised weight-at-age matrices were developed that vary annually (**Tables 3.21 and 3.22**).

Table 3.20. Biological functions used for "base runs".

	Proportion Mature		Fecundity (millions of female eggs)		Natural Mortality	
Age	Atlantic	Gulf	Atlantic	Gulf	Atlantic	Gulf
0	0.000	0.000	0.000	0.000	0.672	0.765
1	0.548	0.157	0.130	0.155	0.256	0.274
2	0.861	0.529	0.250	0.267	0.220	0.243
3	0.924	0.704	0.388	0.395	0.199	0.222
4	0.948	0.856	0.528	0.531	0.186	0.207
5	0.970	0.989	0.662	0.669	0.176	0.196
6	0.989	1.000	0.783	0.801	0.170	0.188
7	1.000	1.000	0.890	0.926	0.165	0.182

8	1.000	1.000	0.981	1.041	0.161	0.177
9	1.000	1.000	1.058	1.145	0.158	0.173
10	1.000	1.000	1.123	1.238	0.156	0.170
11+	1.000	1.000	1.288	1.524	0.152	0.162

Table 3.21. Weight -at-age (kg) matrix used the Atlantic "base run".

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11
1981	0.240	1.508	2.863	3.872	4.836	5.805	6.908	7.760	8.552	9.318	9.719	11.400
1982	0.240	1.508	2.863	3.872	4.836	5.805	6.908	7.760	8.552	9.318	9.719	11.400
1983	0.240	1.508	2.863	3.872	4.836	5.805	6.908	7.760	8.552	9.318	9.719	11.400
1984	0.240	1.508	2.863	3.872	4.836	5.805	6.908	7.760	8.552	9.318	9.719	11.400
1985	0.240	1.508	2.863	3.872	4.836	5.805	6.908	7.760	8.552	9.318	9.719	11.400
1986	0.240	1.195	2.491	3.542	4.215	5.011	5.809	6.788	7.407	8.140	7.860	10.197
1987	0.240	1.195	2.491	3.542	4.215	5.011	5.809	6.788	7.407	8.140	7.860	10.197
1988	0.240	1.195	2.491	3.542	4.215	5.011	5.809	6.788	7.407	8.140	7.860	10.197
1989	0.240	1.195	2.491	3.542	4.215	5.011	5.809	6.788	7.407	8.140	7.860	10.197
1990	0.240	1.195	2.491	3.542	4.215	5.011	5.809	6.788	7.407	8.140	7.860	10.197
1991	0.240	1.741	2.842	3.608	4.486	5.199	6.199	6.933	7.540	8.419	9.128	11.029
1992	0.240	1.741	2.842	3.608	4.486	5.199	6.199	6.933	7.540	8.419	9.128	11.029
1993	0.240	1.741	2.842	3.608	4.486	5.199	6.199	6.933	7.540	8.419	9.128	11.029
1994	0.240	1.741	2.842	3.608	4.486	5.199	6.199	6.933	7.540	8.419	9.128	11.029
1995	0.240	1.741	2.842	3.608	4.486	5.199	6.199	6.933	7.540	8.419	9.128	11.029
1996	0.240	1.545	2.990	4.159	5.293	6.310	7.448	7.781	8.798	9.067	10.243	12.376
1997	0.240	1.545	2.990	4.159	5.293	6.310	7.448	7.781	8.798	9.067	10.243	12.376
1998	0.240	1.545	2.990	4.159	5.293	6.310	7.448	7.781	8.798	9.067	10.243	12.376
1999	0.240	1.545	2.990	4.159	5.293	6.310	7.448	7.781	8.798	9.067	10.243	12.376
2000	0.240	1.545	2.990	4.159	5.293	6.310	7.448	7.781	8.798	9.067	10.243	12.376
2001	0.240	2.043	3.073	4.123	5.056	6.133	7.391	8.482	9.465	10.988	11.776	12.432
2002	0.240	2.043	3.073	4.123	5.056	6.133	7.391	8.482	9.465	10.988	11.776	12.432
2003	0.240	2.043	3.073	4.123	5.056	6.133	7.391	8.482	9.465	10.988	11.776	12.432
2004	0.240	2.043	3.073	4.123	5.056	6.133	7.391	8.482	9.465	10.988	11.776	12.432
2005	0.240	2.043	3.073	4.123	5.056	6.133	7.391	8.482	9.465	10.988	11.776	12.432
2006	0.240	1.508	2.863	3.872	4.836	5.805	6.908	7.760	8.552	9.318	9.719	11.400

Table 3.22. Weight-at-age (kg) matrix used the Gulf "base run".

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11
1981	0.424	1.857	2.817	3.825	4.825	6.005	7.062	8.125	8.942	10.023	10.786	12.835
1982	0.424	1.857	2.817	3.825	4.825	6.005	7.062	8.125	8.942	10.023	10.786	12.835
1983	0.424	1.857	2.817	3.825	4.825	6.005	7.062	8.125	8.942	10.023	10.786	12.835
1984	0.424	1.857	2.817	3.825	4.825	6.005	7.062	8.125	8.942	10.023	10.786	12.835
1985	0.424	1.857	2.817	3.825	4.825	6.005	7.062	8.125	8.942	10.023	10.786	12.835
1986	0.424	1.429	2.630	3.697	4.953	6.605	7.425	8.463	9.388	10.601	10.791	14.727
1987	0.424	1.429	2.630	3.697	4.953	6.605	7.425	8.463	9.388	10.601	10.791	14.727
1988	0.424	1.429	2.630	3.697	4.953	6.605	7.425	8.463	9.388	10.601	10.791	14.727
1989	0.424	1.429	2.630	3.697	4.953	6.605	7.425	8.463	9.388	10.601	10.791	14.727
1990	0.424	1.429	2.630	3.697	4.953	6.605	7.425	8.463	9.388	10.601	10.791	14.727
1991	0.424	1.787	2.868	3.902	5.233	6.426	7.759	8.628	9.079	10.085	11.175	12.155
1992	0.424	1.787	2.868	3.902	5.233	6.426	7.759	8.628	9.079	10.085	11.175	12.155
1993	0.424	1.787	2.868	3.902	5.233	6.426	7.759	8.628	9.079	10.085	11.175	12.155
1994	0.424	1.787	2.868	3.902	5.233	6.426	7.759	8.628	9.079	10.085	11.175	12.155
1995	0.424	1.787	2.868	3.902	5.233	6.426	7.759	8.628	9.079	10.085	11.175	12.155
1996	0.424	1.989	3.166	3.912	4.842	5.877	6.802	8.342	10.015	10.783	11.792	13.103
1997	0.424	1.989	3.166	3.912	4.842	5.877	6.802	8.342	10.015	10.783	11.792	13.103
1998	0.424	1.989	3.166	3.912	4.842	5.877	6.802	8.342	10.015	10.783	11.792	13.103
1999	0.424	1.989	3.166	3.912	4.842	5.877	6.802	8.342	10.015	10.783	11.792	13.103
2000	0.424	1.989	3.166	3.912	4.842	5.877	6.802	8.342	10.015	10.783	11.792	13.103
2001	0.424	2.205	2.700	3.752	4.515	5.644	6.383	7.465	8.311	8.954	9.835	11.276
2002	0.424	2.205	2.700	3.752	4.515	5.644	6.383	7.465	8.311	8.954	9.835	11.276
2003	0.424	2.205	2.700	3.752	4.515	5.644	6.383	7.465	8.311	8.954	9.835	11.276
2004	0.424	2.205	2.700	3.752	4.515	5.644	6.383	7.465	8.311	8.954	9.835	11.276
2005	0.424	2.205	2.700	3.752	4.515	5.644	6.383	7.465	8.311	8.954	9.835	11.276
2006	0.424	1.857	2.817	3.825	4.825	6.005	7.062	8.125	8.942	10.023	10.786	12.835

VPA models assume that the catch-at-age matrix is known without error. As per the recommendation of the SEDAR16-AW panel, the base VPA runs were constructed using a 50/50 mixing assumption which is defined as follows: 50% of the catch in the mixing zone in winter is of Atlantic origin, and 50% is of Gulf. This assumption was used to construct the catch-at-age matrices summarized in **Tables 3.23. and 3.24**.

Table 3.23. Catch-at-age for Atlantic "base run". Includes dead recreational discards and shrimp bycatch.

YEAR	AGE 0	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11+
1981	1572	40929	91967	490431	359065	159937	74445	17525	5139	2523	8351	15507
1982	34897	88275	56220	274298	393903	170238	67469	35987	12792	8784	30446	15783
1983	64856	246550	184379	234067	223375	119537	98117	17377	4571	1227	4499	32315
1984	60338	60613	33887	256122	252638	141253	96851	21031	2201	3595	32413	21815
1985	231157	69218	134553	167574	339599	206094	62100	19329	8846	6264	1005	16881
1986	1104	146195	286293	109075	190402	79391	58391	164003	34869	26607	27512	107085
1987	171	231329	209536	129585	89162	74306	67981	24842	80380	26685	9274	88328
1988	1297	21962	188306	270771	164366	47696	65171	62119	24525	82888	33379	124594
1989	23385	75982	100318	133043	129372	96741	64271	35773	31147	19153	65577	81245
1990	64146	166880	159263	98464	116713	98292	76958	34233	24323	30616	18295	95344
1991	25794	80550	361441	177752	93595	110514	114830	74359	49365	26212	16445	117714
1992	30063	41815	253265	380636	128437	83442	71408	75354	40497	25788	27152	102669
1993	21126	52521	75676	136504	147432	52545	37639	51894	60011	31136	20799	73749
1994	21055	59638	153657	83169	125439	128624	66221	30227	31045	39588	23865	48206
1995	40218	99525	183651	119362	85999	84583	125129	35526	29555	40281	34799	46256
1996	59534	66640	294068	157862	115708	66849	63368	95816	38594	23052	14197	45940
1997	15744	104769	280669	213815	124525	70935	48347	76698	80212	29690	11409	60274
1998	49479	31780	199182	240440	189582	92523	48052	29688	53866	57817	11148	37572
1999	32003	72939	132038	147317	169187	91638	43558	23088	17142	27102	24154	22189
2000	18381	17903	290034	146032	190138	112784	52595	21983	10509	13741	29812	48845
2001	7198	15128	81772	156970	117431	118936	89889	39866	11708	9313	8271	56460
2002	9125	58265	161012	103825	153478	69882	67433	37264	25372	9855	7550	27818
2003	15383	20473	214880	100530	107549	143371	57461	70612	37710	15067	7261	25253
2004	8185	50864	203405	203403	82847	84076	115092	35461	46820	22129	11820	20683
2005	7238	13391	321102	154233	139996	49147	40745	52422	19125	26862	10199	19198
2006	13120	15867	171738	302804	130615	152466	28085	25701	46692	6846	12034	39181

Table 3.24. Catch-at-age for Gulf "base run". Includes dead recreational discards and shrimp bycatch.

YEAR	AGE 0	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11+
1981	563558	16502	32123	216871	193314	48635	27492	21808	9186	3956	4478	14377
1982	243454	54716	180776	153648	207284	149504	65765	17918	17540	20438	6619	175346
1983	476064	91748	189468	105003	26340	44481	30319	6440	9090	4724	1493	16195
1984	1508666	20567	57951	220927	127844	36116	49028	25614	4755	918	1861	17130
1985	732206	23940	56050	94130	72300	83910	31470	12844	18712	4959	1902	17167
1986	815006	36703	209494	80517	34943	54577	39512	12383	2971	6846	575	14812
1987	1477266	99255	77574	32265	25616	29870	16917	8010	4597	3468	2208	6704
1988	1695068	46813	97259	88300	64139	31361	68867	29739	6050	13561	13274	33536
1989	2743625	122445	163030	81732	70834	52482	12200	22971	10889	4445	6203	16935
1990	2093282	104655	163800	105030	73158	35254	37946	7373	18872	8489	1626	18612
1991	2019187	182252	240676	127600	70578	39801	27502	12904	4475	19490	5126	12161
1992	1466838	65491	200838	182078	103020	54354	47024	21010	34006	9313	16888	24785
1993	2812413	60138	146028	151588	134914	62068	36287	25513	24429	13000	1661	34235
1994	3138105	126336	154850	124591	162044	117838	68954	41251	24627	19865	39629	33969
1995	2742216	47871	174393	162710	103136	64878	67180	31299	17621	7851	10630	16723
1996	1376113	87094	242333	156665	86928	53091	35928	35028	27723	12873	2794	41110
1997	1348322	54227	153386	203561	103652	71213	45217	45932	29291	21473	8579	28477
1998	1193085	58339	118231	153169	168698	71258	39946	24472	17403	20184	9092	7159
1999	1210741	45716	127966	94029	116636	88794	28844	27385	19486	22445	3109	11011
2000	1078106	64037	134236	175846	98004	63813	28820	33574	8830	14003	10681	17482
2001	772155	48512	145760	146855	117572	69132	47701	42979	25854	7766	6992	28300
2002	641205	70633	204402	130239	112020	73224	39778	30365	30256	15391	7387	21823
2003	1542801	27247	151935	158851	96919	67925	58810	25398	25196	17727	15759	17722
2004	2888086	33563	230128	129788	105691	54044	42874	37388	10928	22677	6758	14034
2005	1909290	23552	164254	175586	122746	76873	52471	41831	29796	11442	10628	27227
2006	923292	20093	178244	203485	158511	107711	58659	42905	28343	16720	8995	28893

The VPA "base runs" used the updated indices developed for SEDAR 16 SS3 runs. These are summarized in **Table 3.25 and 3.26**. Index CVs were used to estimate index variance.

Table. 3.25. Indices of abundance and index settings used for the Atlantic VPA "base run". Indices were rescaled to the 1981-2006 time period when necessary.

	Trip Ticket - NC PIDs 8+		MRFSS-Atl-No-Mix		HB-Atl-no-Mix		SEAMAP South Alt.	
Type of Index	Fish. Dep. COM		Fish. Dep. REC		Fish. Dep. REC		Fish. Independent	
Unit	Weight		Number		Number		Numbers	
Likely Applies to Ages	Ages 1-11+		Ages 1-11+		Ages 1-11+		Age 0 Mid-Year	
YEAR	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV
1981			1.194	0.723	1.506	0.476		
1982			1.386	0.650	0.757	0.497		
1983			1.396	0.671	1.236	0.387		
1984			1.487	0.648	0.769	0.295		
1985			1.399	0.611	0.595	0.302		
1986			4.424	0.532	0.734	0.235		
1987			1.700	0.575	0.858	0.235		
1988			1.202	0.576	0.816	0.238		
1989			0.962	0.565			0.807	0.212
1990			0.879	0.591			2.377	0.158
1991			1.193	0.568	1.170	0.242	0.704	0.222
1992			0.946	0.576	1.517	0.224	0.843	0.241
1993			0.548	0.645	0.805	0.238	0.446	0.247
1994	0.700	0.068	0.355	0.679	0.614	0.249	0.708	0.232
1995	0.744	0.073	0.399	0.681	0.617	0.232	1.226	0.198
1996	1.125	0.069	0.342	0.677	0.464	0.240	2.261	0.168
1997	1.033	0.060	1.126	0.569	1.218	0.206	0.519	0.240
1998	1.056	0.060	0.544	0.617	1.243	0.209	1.786	0.200
1999	0.969	0.061	0.937	0.590	0.976	0.218	1.213	0.184
2000	0.986	0.059	0.811	0.605	1.854	0.209	0.816	0.221
2001	1.044	0.057	0.407	0.660	1.288	0.213	0.448	0.234
2002	0.907	0.069	0.188	0.779	0.886	0.241	0.506	0.211
2003	0.879	0.073	0.271	0.717	0.912	0.227	0.989	0.196
2004	1.292	0.058	0.462	0.649	0.896	0.223	0.619	0.357
2005	1.206	0.063	0.843	0.577	1.496	0.254	0.726	0.493
2006	1.058	0.066	0.598	0.621	1.147	0.219	1.006	0.221

Table. 3.26. Indices of abundance and index settings used for the Gulf VPA "base run". Indices were rescaled to the 1981-2006 time period when necessary. For the SEAMAP Groundfish Survey, values of 0.0 were replaced with the series minimum and the CV was set to the series average (SEDAR16 DW recommendation).

	Com Logboof Gulf-No Mix		MRFSS-Gulf-No-Mix		HB-Gulf-no-Mix		SEAMAP Fall Groundfish		SEAMAP Fall Plankton (Larval)	
Type of Index	Fish. Dep. REC		Fish. Dep. REC		Fish. Dep. REC		Fish. Independent		Fish. Independent	
Unit	Biomass		Number		Number		Numbers		Numbers	
Likely Applies to Ages	Ages 1-11+		Ages 1-11+		Ages 1-11+		Age 0		Ages 1 to 11+, using partial selection	
YEAR	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV	STDCPUE	CV
1981			0.722	0.424			***0.018***	***0.600***		
1982			0.467	0.407			***0.018***	***0.600***		
1983			0.883	0.428			***0.018***	***0.600***		
1984			0.501	0.390			0.101	0.911		
1985			0.550	0.417			0.045	0.823		
1986			0.451	0.338	0.677	0.184	0.085	1.080	0.116	0.534
1987			1.077	0.303	0.699	0.175	0.018	1.482	0.379	0.322
1988			0.710	0.324	0.809	0.194	0.122	0.527	0.613	0.437
1989			0.923	0.332	0.799	0.186	0.101	0.702	0.845	0.326
1990			1.292	0.318	0.558	0.170	0.162	0.409	0.648	0.321
1991			1.263	0.301	1.371	0.156	0.063	0.565	0.721	0.318
1992			1.002	0.293	1.234	0.153	0.096	0.559	0.596	0.237
1993	0.720	0.132	0.998	0.301	0.838	0.151	0.424	0.325	1.251	0.199
1994	0.881	0.101	1.243	0.290	1.205	0.133	0.183	0.480	1.050	0.231
1995	0.990	0.093	1.115	0.305	1.295	0.134	0.108	0.641	1.979	0.195
1996	0.974	0.078	1.322	0.299	1.437	0.142	0.087	0.532	0.741	0.265
1997	1.307	0.069	1.480	0.285	1.307	0.140	0.209	0.425	1.360	0.201
1998	1.288	0.068	1.083	0.286	1.084	0.145	0.224	0.413		
1999	1.118	0.065	0.922	0.281	1.286	0.150	0.177	0.396	0.920	0.225
2000	1.068	0.062	1.213	0.276	0.890	0.153	0.202	0.480	0.922	0.273
2001	1.055	0.064	1.114	0.280	0.686	0.160	0.252	0.376	1.642	0.203
2002	0.994	0.061	1.239	0.276	0.729	0.150	0.144	0.536	1.451	0.214
2003	0.985	0.069	0.967	0.282	1.055	0.153	0.566	0.289	1.103	0.219
2004	0.923	0.073	1.019	0.281	0.654	0.162	0.450	0.308	1.478	0.211
2005	0.732	0.093	0.860	0.290	1.038	0.163	0.491	0.292		
2006	0.966	0.083	1.584	0.276	1.351	0.149	0.381	0.369	1.187	0.253

For most indices, selectivity (*S*) by age and year was estimated using partial catches. In the Atlantic there was one exception, the SEAMAP South Atlantic Trawl survey. This survey was assumed to index the abundance of age-0 king mackerel in October-November. Therefore, for all years $S_0$was fixed to 1.0 and $S_{1\text{-}11+}$ were fixed to 0.0. In the Gulf there were two exceptions: the Shrimp Bycatch GLM which was assumed to index age-0 king mackerel ($S_0$was fixed to 1.0 and $S_{1\text{-}11+}$ were fixed to 0.0) and the SEAMAP Ichthyoplankton survey which was assumed to index spawning stock biomass. For the SEAMAP survey, the selectivity pattern was fixed at maturity*fecundity-at-age. The partial catches used to estimate selectivity for each index are summarized in **Tables 3.27 and 3.28**. The equation used to estimate selectivity was that corresponding to Butterworth and Geromont (1999) (see VPA-2BOX manual), instead of the Powers and Restrepo (1982) method. While the Powers and Restrepo approach allows selectivity at age to change every year, the Butterworth and Geromont approach computes an average selectivity pattern for the entire time period.

Table 3.27. Partial catches at age (numbers) used in the Atlantic VPA “base run”.

Index	Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11
NC Trip Ticket	1981	0	1504	4919	30522	32629	4268	8986	153	239	59	253	896
	1982	40	32852	1510	22594	16388	13275	8784	5667	65	483	9966	473
	1983	3190	10865	4527	9850	23330	15344	11832	1890	1837	216	160	2651
	1984	9	9718	2586	4024	16817	10940	7474	4426	569	248	94	4108
	1985	3	4738	9130	8532	16293	19842	6716	5081	2589	1861	337	2795
	1986	37	7342	17967	8993	19344	7595	5549	17712	3050	2968	3569	11753
	1987	0	5863	12365	26358	15931	11586	12582	5459	17225	6166	1896	18692
	1988	0	675	9375	19895	15397	5171	4674	6513	2661	7688	3259	10586
	1989	0	5295	10702	17720	18285	13207	9450	4387	3322	2463	5914	7431
	1990	0	16135	25230	16424	23180	21449	16264	7603	4489	3971	2054	12173
	1991	0	2543	34410	26931	13234	14032	12930	8360	4304	1968	1321	7701
	1992	0	1104	20975	45638	18942	9619	7041	7609	4714	2607	1909	6113
	1993	40	2951	8926	15434	18020	6128	4967	5307	5626	3317	1861	6050
	1994	0	1967	12133	9653	12249	16300	11453	4540	4740	6810	3873	7160
	1995	0	2876	11556	12118	8915	9800	14178	4550	3691	5570	4520	3979
	1996	0	9873	55236	27256	16837	8677	7448	11680	4204	1645	1799	3878
	1997	0	4228	21785	21117	16116	7627	5887	9754	11524	4418	1678	6965
	1998	3	1404	31524	48158	27108	13262	5260	3172	4312	6171	1412	2643
	1999	0	11092	25162	26338	27829	11077	5480	1996	1989	2256	2152	2026
	2000	0	336	18488	14034	22654	14703	7700	2806	1324	1473	3004	4947
	2001	0	2370	5690	13311	13786	12383	10541	4957	2548	1279	2197	8823
	2002	66	5751	20231	7612	11692	8443	8731	5227	3531	1364	723	4593
	2003	0	636	17661	6549	8028	11278	3812	5051	2655	999	568	2048
	2004	0	13848	48800	34283	12643	8865	12398	3165	3878	1932	730	1543
	2005	0	1362	56377	28686	21449	7854	4655	7552	2211	4095	1534	2906
	2006	0	962	28832	44380	11078	15692	1910	2034	5422	772	3436	8193
Commercial – Mixing Zone	1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1990	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1993	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1995	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1996	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

	1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2002	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2004	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2005	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MRFSS	1981	0	8188	38184	130232	78134	88326	33724	4725	2467	476	3	8092
	1982	20446	34912	2532	100864	172443	68561	28449	16528	2047	6094	12271	5390
	1983	32513	147194	85315	110399	93197	42893	31364	9992	3	0	244	8459
	1984	42582	34124	13668	162449	137083	63195	59346	695	11	1548	23883	11213
	1985	176491	40223	76590	39543	189676	84440	28961	459	745	1392	6	2568
	1986	513	65220	108755	36962	65517	27845	16080	45779	10757	7323	7595	29585
	1987	0	134158	109577	49600	32163	26062	22879	7545	25233	8272	2589	26171
	1988	0	6270	74927	98384	54407	13778	16520	20673	7871	28362	9422	41576
	1989	0	30908	25645	42794	37957	26578	20457	11001	10208	6418	23999	25879
	1990	0	87568	50872	30377	45527	38966	28920	13053	8990	12983	8205	41375
	1991	0	34831	142445	48788	25190	37040	38765	24445	17712	8361	4856	42847
	1992	1873	22951	96435	143514	35934	26493	25760	30547	11829	9495	9606	42078
	1993	6132	30604	15722	44827	48784	15580	13635	23535	27277	13315	9402	37469
	1994	0	41402	55901	26393	42617	49990	21643	10632	12709	15981	8230	19727
	1995	0	70971	98465	44333	30418	31855	48138	10298	10192	16139	13574	17422
	1996	0	14772	73378	41192	36955	23884	25043	36619	11819	7313	6662	17402
	1997	0	39696	99371	69327	42974	23200	19162	34005	35551	10599	4641	29042
	1998	1171	8472	63201	71747	47935	27521	14212	10052	22271	21902	3326	17565
	1999	0	37162	38884	62541	72558	36998	19874	9041	8417	13589	13542	11789
	2000	0	6218	169689	53926	93018	52625	22945	8162	5013	7002	17563	29404
	2001	0	6051	28773	64549	43052	55512	43799	19177	4125	3745	3852	31699
	2002	451	25332	27811	34422	70591	24671	31116	15686	10014	3379	2635	12134
	2003	0	10460	108202	35760	57796	87338	28917	43866	22829	7781	3240	14605
	2004	0	22642	38660	78059	25506	36416	54047	13918	23516	10647	6821	11380
	2005	0	5774	155331	54726	62701	16299	15131	22471	6800	11469	3678	5909
	2006	0	7063	73389	145726	55424	77017	9423	9466	21134	1624	5421	15563
Headboat	1981	0	17710	24204	128409	58857	66710	25138	742	207	191	3830	7374
	1982	357	21793	600	47553	37759	11211	6929	2991	412	1191	7082	438
	1983	4089	111447	16974	31766	38074	8027	13794	1452	53	0	20	2296
	1984	38760	16159	7597	41634	44727	24793	22032	521	134	250	8991	4032
	1985	183115	26635	36220	28374	164470	73614	21068	1	448	1010	44	1951
	1986	68	6143	3863	1477	2885	1046	545	2389	351	324	392	1451
	1987	0	843	888	628	327	254	256	69	363	93	21	264
	1988	0	118	1497	1902	999	250	268	365	172	569	196	1009

	1989	0	926	696	875	781	552	437	232	208	139	448	622
	1990	0	7476	1533	883	1361	1086	765	336	214	286	157	844
	1991	0	965	4255	1330	629	968	986	603	439	199	107	1025
	1992	1	99	749	964	236	151	142	137	55	48	61	166
	1993	92	841	631	1030	1190	477	348	399	444	245	146	534
	1994	0	706	1645	623	1346	1190	826	294	373	469	189	837
	1995	0	803	982	415	345	438	606	136	146	254	185	228
	1996	0	129	576	516	435	247	257	376	158	103	60	184
	1997	0	1247	2497	1740	1326	880	550	865	896	322	110	681
	1998	15	108	17935	14123	9795	6585	4515	3020	6802	6753	1215	4048
	1999	0	965	430	634	478	199	132	55	77	83	114	70
	2000	0	63	1313	351	558	280	110	37	24	27	67	99
	2001	0	235	647	1294	806	1015	650	382	132	74	159	863
	2002	29	1614	1755	2317	4692	1778	2494	1261	841	263	172	1063
	2003	0	227	1304	309	437	630	178	286	145	49	22	108
	2004	0	717	742	982	302	399	602	175	279	147	79	212
	2005	0	57	1428	449	512	119	116	162	47	100	34	64
	2006	0	214	2196	4634	1369	1492	196	156	377	39	127	177

Table 3.28. Partial catches at age (numbers) used in the Gulf VPA "base run".

Index	Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11
Commercial Logbook – Gulf No Mix	1981	0	3	703	1240	1154	500	40	37	34	0	0	121
	1982	21	378	503	985	587	11	700	6	0	0	0	443
	1983	0	1065	3212	679	168	161	63	147	5	43	25	104
	1984	0	111	377	1815	592	41	257	57	1	1	28	35
	1985	0	2	18	361	279	203	17	42	24	2	0	9
	1986	5	194	554	2	50	60	53	3	14	2	10	12
	1987	0	2088	1309	252	167	199	73	55	24	12	5	26
	1988	8	279	692	341	166	77	226	68	11	35	33	120
	1989	0	6491	913	481	343	30	2	15	9	4	9	24
	1990	0	1301	1384	729	187	138	94	25	119	38	10	58
	1991	29	3172	3265	1100	462	587	273	141	32	337	52	119
	1992	0	2796	4525	2246	424	155	364	105	102	23	153	89
	1993	21	781	1295	2169	1540	582	257	494	155	73	22	591
	1994	0	4089	1411	1648	2335	2122	881	183	829	443	120	1048
	1995	4	252	620	550	734	561	664	300	126	156	139	182
	1996	0	5898	6904	4405	1296	1042	1265	753	168	44	108	273
	1997	0	2320	9104	9059	5377	2891	2464	3395	1121	319	0	1282
	1998	0	3159	2231	2914	1284	677	363	260	299	204	118	72
	1999	0	1843	1542	2780	3501	2443	1088	540	904	987	165	500
	2000	0	1005	2985	3118	2367	2038	541	1196	256	372	493	741
	2001	0	1059	2786	3346	2435	2313	2004	1698	1180	123	378	1028
	2002	5	2525	1848	2042	1911	941	829	828	752	364	114	526

	2003	0	2274	5758	3536	3066	2260	1235	602	961	506	414	543
	2004	0	539	1427	1382	1250	817	754	332	166	266	123	154
	2005	1	164	614	392	506	290	149	123	44	43	44	92
	2006	0	317	1728	1744	1021	1306	935	597	447	152	101	422
MRFSS	1981	1068	2156	7145	41847	14425	2769	1550	1880	1917	0	0	345
	1982	1607	20562	37782	37429	4905	11347	1992	30	0	0	90	571
	1983	94	77651	98962	15428	1927	6354	1753	1884	498	502	0	7633
	1984	39806	6330	24190	109998	43561	1190	5170	6204	42	16	87	1706
	1985	4012	17349	24319	5808	6338	5665	3442	111	58	0	0	2200
	1986	3039	27599	99309	17326	11877	11523	8244	1011	331	120	0	1229
	1987	492	98316	74412	18767	13552	15500	7199	4749	2011	1022	655	1478
	1988	3445	50826	95571	72928	44262	19984	54535	15909	3105	8615	8507	17588
	1989	517	113466	86703	36915	29287	10915	1077	7648	2337	1645	1184	2842
	1990	0	77131	89827	49552	17065	9350	6722	1441	5912	2009	358	4932
	1991	1674	188231	193026	55409	23918	21880	7291	5755	1473	9004	2887	5764
	1992	0	35185	100586	69668	28111	19411	17048	9532	18466	3828	6699	13261
	1993	1177	48264	50118	67882	50679	20273	8613	11863	6340	3472	623	12987
	1994	0	94133	43423	38399	51762	36049	18038	6602	10778	5930	6326	9942
	1995	1518	23527	34532	29126	27246	21292	21969	11786	5563	3956	4537	6195
	1996	0	66450	90163	53444	28021	21906	20218	16637	10734	4526	1561	16539
	1997	0	30159	83391	84134	43674	26516	19167	20989	10370	6359	1671	10800
	1998	0	48027	51515	69122	53603	26182	15056	9125	8550	5815	3466	2127
	1999	0	59123	45134	39316	43018	30448	11135	8981	7992	8628	1010	4123
	2000	0	44814	73905	66708	33365	18979	6433	10605	2097	3657	2887	4302
	2001	0	37468	51173	38974	25587	18102	14190	12556	9509	3464	2069	9316
	2002	137	59917	111944	56858	42353	24268	17109	13561	13095	6974	3041	9425
	2003	0	18165	63634	43070	33763	24194	15261	6806	8717	5210	4307	4711
	2004	0	26349	69598	36378	30941	17858	15349	10805	4344	6838	2792	4711
	2005	129	11677	50633	32972	32817	19070	13008	9591	6826	2760	2488	8976
	2006	0	22819	102724	84297	54069	47854	26749	17696	13102	7204	2933	12742
Headboat	1981	3	990	446	985	699	369	92	14	58	0	0	123
	1982	3	990	446	985	699	369	92	14	58	0	0	123
	1983	3	990	446	985	699	369	92	14	58	0	0	123
	1984	3	990	446	985	699	369	92	14	58	0	0	123
	1985	3	990	446	985	699	369	92	14	58	0	0	123
	1986	302	4068	20317	5478	1272	2051	1199	554	0	123	0	25
	1987	6	1885	1250	389	289	292	159	85	44	30	24	26
	1988	56	874	1058	927	666	191	286	174	42	58	55	57
	1989	4	4172	9297	3069	960	862	90	221	62	39	4	61
	1990	0	5219	7086	3118	1397	559	435	51	241	85	18	294
	1991	44	3493	7537	2708	1138	673	279	172	56	194	49	94
	1992	0	4153	5998	4173	1485	888	434	204	510	83	50	198
	1993	85	1701	7781	4552	2561	900	389	214	367	153	6	210
	1994	0	1450	6494	2450	2513	1054	544	220	297	199	81	176

	1995	23	930	4503	3144	1232	484	426	121	51	45	33	36
	1996	0	3565	9044	5082	2435	1162	1016	701	419	259	52	408
	1997	0	3502	9300	4833	1239	476	252	239	115	68	43	63
	1998	0	3492	1844	1731	1441	476	198	108	56	58	26	8
	1999	0	2419	4453	2113	1800	1049	360	421	111	101	12	67
	2000	0	1102	3262	2784	933	495	198	215	53	68	33	54
	2001	0	405	1066	988	794	498	293	296	202	116	22	194
	2002	2	1085	1975	756	505	312	165	105	102	64	33	64
	2003	0	608	2676	1458	618	308	262	93	51	54	36	44
	2004	0	809	7307	1827	1217	470	398	574	102	389	47	139
	2005	6	1729	8130	3939	1694	752	341	312	198	66	49	187
	2006	0	280	4536	3868	2815	1102	487	404	189	213	45	239

3.2.1.3. Model Configuration and Equations

The model configuration and equations are identical to those described in Section 3.1.1.3. except that:

1) Indices were weighted equally while preserving interannual variations (see document AW-XXX Restrepo et al for the methodology used). This was accomplished by fixing the variance scaling parameters to the values in **Table 3.29**.

Table 3.29. Fixed variance scalars used to equally weight the indices of abundance.

Region	Index	Variance Scalar
ATL	NC_TT	0.574532
	MRFSS_ATL_NOMIX	0.000000
	HEADBOAT_NOMIX	0.512862
	SEAMAP_SA_TRAWL	0.525378
Gulf	COM_GULF_NOMIX	0.536934
	MRFSS_GULF_NOMIX	0.443338
	HEADBOAT_GULF_NOMIX	0.519944
	SEAMAP_GROUNDFISH	0.000000
	SEAMAP_PLANKTON	0.466586

2) The index vulnerabilities were estimated using partial catches fit using the method of Butterworth and Geromont (1999) rather than Powers and Restrepo (1992) method. While the Powers and Restrepo approach allows selectivity at age to change every year, the Butterworth and Geromont approach computes an average selectivity pattern for the entire time period.

3) A penalty was used to constrain changes in vulnerability during the most recent three years. This penalty (SD = 0.4) was applied to ages 3 – 9. (In undocumented runs, the analysts tried SD values of 0.3, 0.4 and 0.6 and they made negligible differences)

3.2.1.4. Parameters Estimated

For the VPA "base runs", the age-0 to age-10 terminal F parameters were estimated using the following initial conditions and settings (**Table 3.30**). The plus group Terminal F was fixed at the value estimated for Age-10.

Table 3.30. Terminal F settings and initial conditions used for the sensitivity runs.

	Atlantic		Gulf	
	Initial Value	Fixed or Estimated?	Initial Value	Fixed or Estimated?
Age 0	0.15	Estimated	0.15	Estimated
Age 1	0.15	Estimated	0.15	Estimated
Age 2	0.15	Estimated	0.15	Estimated
Age 3	0.15	Estimated	0.15	Estimated
Age 4	0.15	Estimated	0.15	Estimated
Age 5	0.15	Estimated	0.15	Estimated
Age 6	0.15	Estimated	0.15	Estimated
Age 7	0.15	Estimated	0.15	Estimated
Age 8	0.15	Estimated	0.15	Estimated
Age 9	0.15	Estimated	0.15	Estimated
Age 10	0.15	Estimated	0.15	Estimated
Age 11+	-	Fixed equal to Terminal F at Age-10	-	Fixed equal to Terminal F at Age-10

3.2.1.5. Uncertainty and Measures of Precision

Estimation uncertainty was determined by running 1000 non-parametric bootstraps of the index residuals. These bootstraps allow computation of the maximum likelihood estimate (MLE), bootstrap average, bias, standard error and coefficients of variation (CVs) for each parameter. In addition, bootstrapping allows the computation of upper and lower 80% confidence intervals on the annual estimates of SSB, R and F (illustrated with dashed lines in the figures below).

3.2.1.6. Methods Used to Compute Benchmark / Reference Points

Benchmarks and reference points were calculated using the proposed management criteria[4] (**Table 3.31**).

[4] Julie Neer. SEDAR Coordinator. Provided to SEDAR16-AW 4/30/2008. Julie.Neer@safmc.net

Table 3.31. Proposed management criteria for the Gulf and South Atlantic regions.

Criteria	Definition - Proposed	
	South Atlantic	Gulf
MSST	MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}	MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}
MFMT	F_{MSY}	F_{MSY}
MSY	Yield at F_{MSY}	Yield at F_{MSY}
F_{MSY}	F_{MSY}	F_{MSY}
OY	Yield at F_{OY}	Yield at F_{OY}
F_{OY}	F_{OY} =65%, 75%, 85% F_{MSY}	F_{OY} =65%, 75%, 85% F_{MSY}
M	0.1603 (Base of Lorenzen M)	0.1738(Base of Lorenzen M)

There are a number of ways in which F_{MSY} could be estimated. With age-structured production models such as the VPA used in SEDAR16, it is sometimes estimated by combining yield-per-recruit and spawner-per-recruit calculations with an estimated stock-recruitment relationship. The Assessment Workshop chose not to fit freely a stock-recruitment relationship to the VPA estimates of SSB and recruitment, but rather to fix a relationship which predicted nearly-constant recruitment. In such a situation of nearly-constant recruitment, F_{MSY} would be approximately equal to F_{MAX}, the F that maximizes yield-per-recruit. However, since recruitment is not likely to remain constant at low SSB levels, F_{MAX} is likely to overestimate F_{MSY}.

The use of a SPR-based proxies for F_{MSY} is recommended when there is no evidence of a strong stock-recruitment relationship, as is the case with Atlantic and Gulf king mackerels. The Assessment Workshop chose to continue using $F_{SPR30\%}$ as a proxy for F_{MSY}, as used for king mackerels since the late 1990s. Therefore, the benchmarks are measured as follows:

Estimated by $F_{30\%}$
B_{MSY} = Estimated by the equilibrium SSB resulting from fishing at $F_{30\%}$ and assuming the equilibrium stock-recruitment relationship below.
MSY = Estimated by the equilibrium yield resulting from fishing at $F_{30\%}$ and assuming the equilibrium stock-recruitment relationship below.

The following treatments of the data and assumptions have been used in making the corresponding calculations:

Terminal F ($F_{Current}$): $F_{Current}$ was estimated as the apical F for the terminal year.

Current Selectivity: selectivity was computed from the geometric means of the age-specific fishing mortality values in the last five years of the VPA.

SSB: SSB is computed as the product of numbers at age at the beginning of each year, times maturity, times fecundity.

Expected spawner-recruit relationship: Assumed a Beverton-Holt relationship with a steepness of 0.95 (i.e. recruitment is nearly constant at most levels of SSB).

Appendix 1, prepared by the authors, provides some notes about possible inconsistencies that can result from estimating current F and current selectivity from different years as has been done here as requested by the AW.

3.2.1.7. Projection methods

Following the recommendation of the SEDAR AW panel, projections of the population dynamics of each stock used a stock recruitment relationship estimated assuming a constant relative recruitment. The S-R relationship was defined using a fixed high steepness (0.95) and a Berverton-Holt S-R function. Maximum expected recruitment was set equal to the geometric mean of VPA estimated recruits over the years for which indices of stock and recruitment were both available (1981-2004 GOM and 1989-2004 ATL).

Because VPA models are backwards recursive and the recruitment estimates during the most recent years are poorly estimated, the SEDAR16 panel recommended replacing the 2005 and 2006 VPA recruitment estimates with the estimates from the S-R relationship.

Projections were run to 2016 using the projection software PRO-2BOX (Porch, 2002b). To estimate the variance of the projection, 1000 bootstraps were run off the VPA results. Although the alpha and beta parameters of the S-R relationship were fixed, the predicted recruitment of each bootstrap was allowed to vary with a CV calculated from the SSB-R observations (Section 3.2.2.9).

Seven types of projections at constant F were made for the period 2007-2016:

1. Project at $F_{Current}$
2. Project at F_{MSY} (= F_{SPR30})
3. Project at F_{SPR40}
4. Project at F_{OY} (=65% F_{SPR30})
5. Project at F_{OY} (=75% F_{SPR30})
6. Project at F_{OY} (=85% F_{SPR30})

3.2.2. Results

VPA base runs were made with and without the application of a "recruitment patch" (replacing the 2005 and 2006 recruitments with values from the S-R relationship as explained in a previous section). The SEDAR16-AW panel recommended the use of the recruitment patch, but the authors have found that this decision may have important and unexpected implications, particularly for the Gulf of Mexico migratory unit. Specifically, the replacement of higher-than-average recruitment in 2005 and 2006 with lower values from the S-R relationship cause an extremely large estimate of apical-F on Age-0 in 2005 (**Figure 3.15**). This is due to replacing the recruitment without modifying the associated shrimp bycatch estimate (Age-0). Because the VPA model must fit catch-at-age exactly, the model must assume that the high shrimp bycatch in 2005 was caused by high fishing mortality rather than high abundance. Since this result was not anticipated, we have preserved the base run using the original VPA recruitment estimates for comparison and for further consideration by the SEDAR16-RW panel.

3.2.2.1. Measures of Overall Model Fit

The model fit was assessed using the objective function, likelihood statistics (**Table 3.32)** and the fits to the indices of abundance (**Figures 3.8 and 3.9**). AIC, AICC and BIC values are also summarized in **Table 3.32**, but these are not directly comparable across model with different numbers of parameters. The base models did not incur any out-of-bounds penalties. The non-zero values for the constraint on terminal F were caused by a penalty applied to limit changes in vulnerability during recent years (2004-2006, Ages 3-9, SD=0.4).

Table 3.32 Likelihood Statistics for base models.

Model	ATL-Mix50%		GOM-Mix50%	
Total objective function	-29.56		-35.54	
(with constants)	44.87		61.87	
Number of parameters	15		16	
Number of data points	81		106	
AIC	119.75		155.74	
AICC	127.13		161.86	
BIC	155.66		198.36	
Chi-square discrepancy	58.79		57.18	
Loglikelihoods (deviance)	19.22		27.3	
effort data	19.22		27.3	
Log-posteriors	0		0	
catchability	0		0	
f-ratio	0		0	
natural mortality	0		0	
mixing coeff.	0		0	
Constraints	10.34		8.23	
terminal F	10.34		8.23	
stock-rec./sex ratio	0		0	
Out of bounds penalty	0		0	
Log Likelihoood: Indices of Abundance	19.23		27.31	
Index 1	NC_TT	6.47	COM_GULF_NOMIX	6.79
Index 2	GULF_MIX	Not Used	MRFSS_GULF_NOMIX	11.69
Index 3	MRFSS_ATL_NOMIX	3.22	HEADBOAT_GULF_NOMIX	8.33
Index 4	HEADBOAT_NOMIX	6.55	SEAMAP_GROUNDFISH	-4.77
Index 5	SEAMAP_SA_TRAWL	2.99	SEAMAP_PLANKTON	5.27

The fits to the abundance indices are summarized in **Figures 3.8 and 3.9**. In the Atlantic, the fits to the indices of abundance were generally poor, although the predicted trends are roughly similar to the observed series.

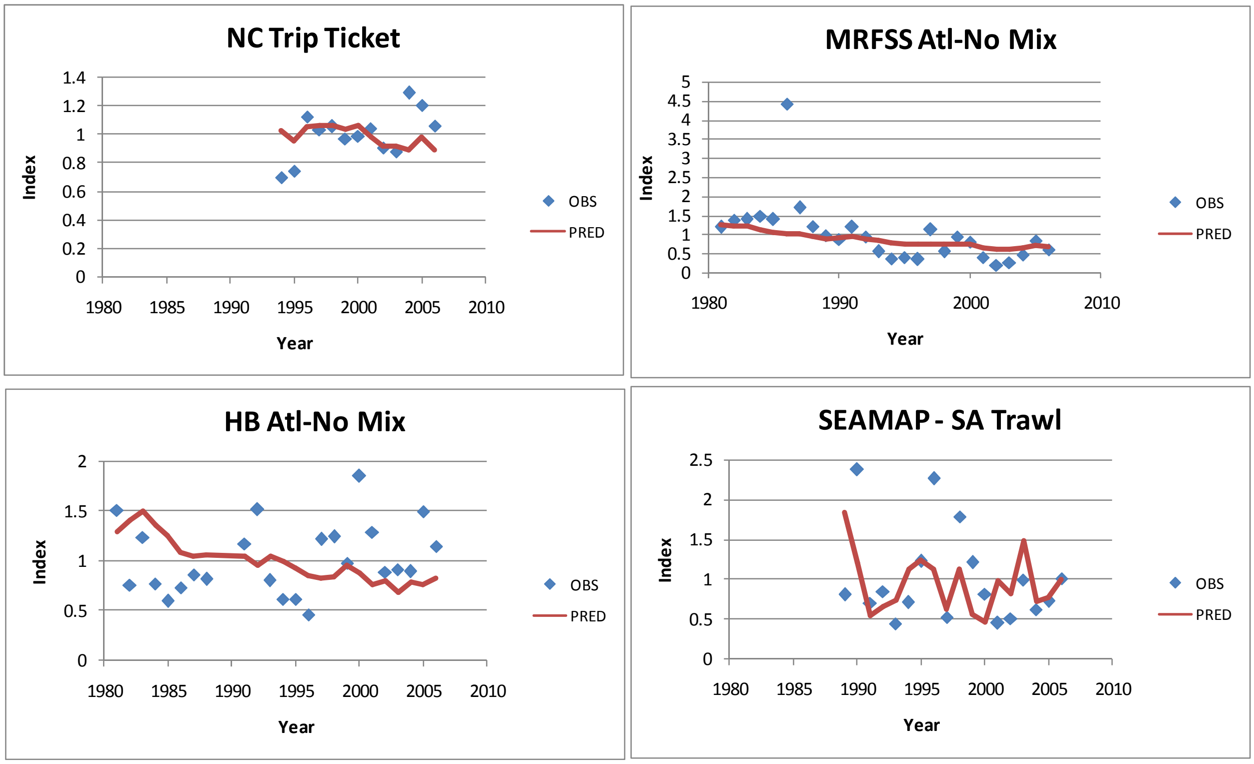


Figure 3.8. Fits to the indices of abundance for the Atlantic base case.

In the Gulf, the fits to the indices of abundance are generally better, particularly the fishery-independent ones that have an upward trend in recent years **(Figure 3.9)**. The Gulf of Mexico commercial index is not fit well. As per the instructions of the SEDAR 16 AW panel, the indices were weighted such that the interannual variations were preserved, but the overall variances were equal for all indices. Using this weighting scenario, it was not possible to closely fit the commercial index because it conflicts (in trend) with the majority of the other indices. However, the AW felt that the lack of fit to the fisheries-dependent indices was justified by the closer fit to the SEAMAP groundfish and Ichthyoplankton surveys. These are fisheries independent, and as such, the panel argued that they should be fit reasonably well, even at the expense of the commercial index. Because the various indices conflict in trends, the choice of how the indices are weighted has a substantial impact on the results.

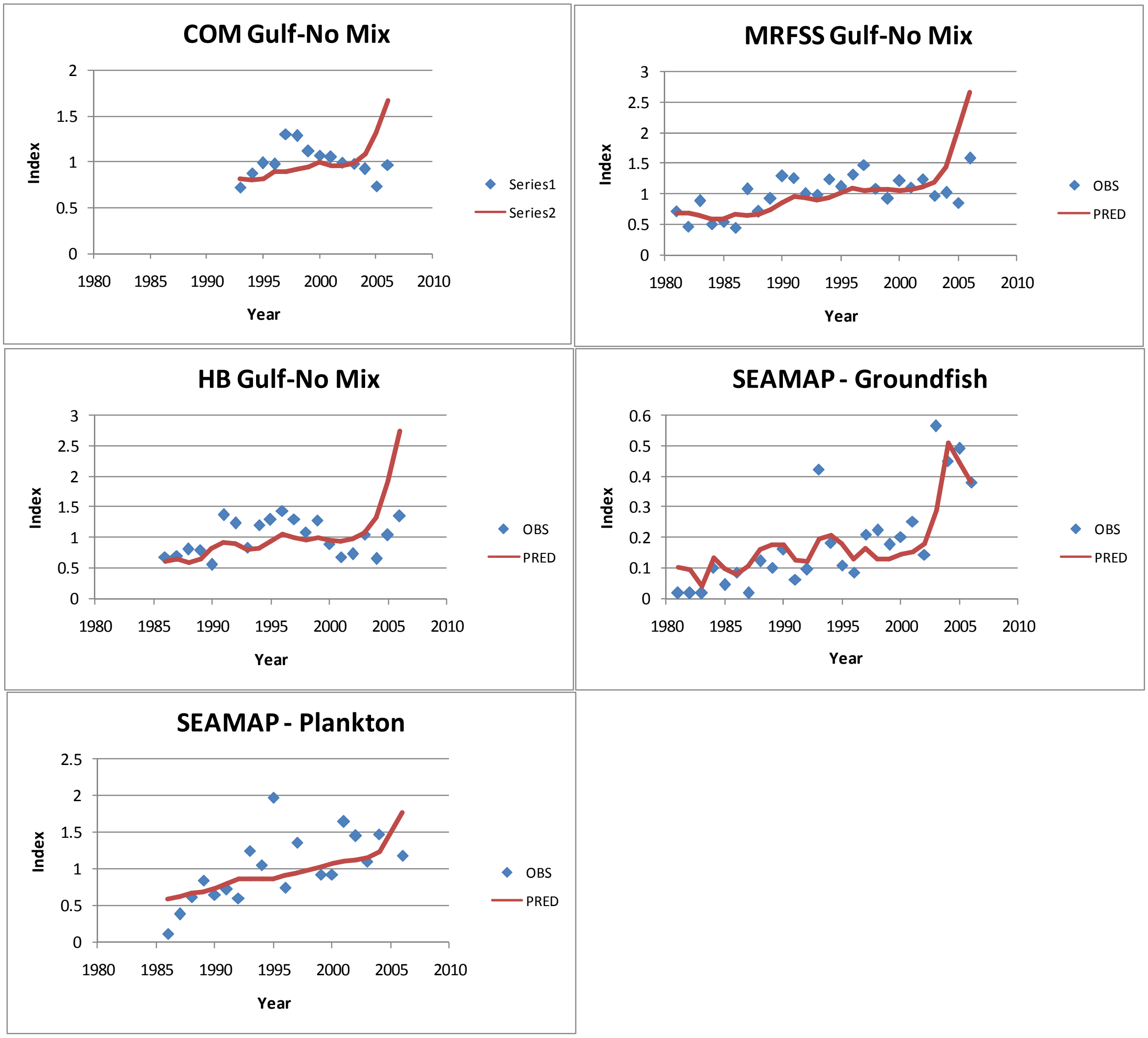


Figure 3.9. Fits to the indices of abundance for the Gulf base case.

3.2.2.2. Parameter estimates & associated measures of uncertainty

Parameter estimates and the associated maximum likelihood estimate (MLE), bootstrap average, bias, standard error and coefficients of variation (CVs) are summarized in **Tables 3.33 and 3.34**. In addition, upper and lower 80% confidence intervals on the annual estimates of SSB, R and F (illustrated with dashed lines) were calculated from the non-parametric bootstraps.

Table 3.33. Final values for estimated parameters of the Atlantic "base runs".

TERMINAL AGE STRUCTURE OF POPULATION ABUNDANCE

Age	MLE	Average of bootstraps	Bias	Std. Error	% CV
1	0.240E+07	0.276E+07	0.374E+06	0.145E+07	52.4
2	0.142E+07	0.168E+07	0.207E+06	0.107E+07	63.6
3	0.919E+06	0.110E+07	0.163E+06	0.737E+06	66.9
4	0.127E+07	0.125E+07	0.194E+05	0.369E+06	29.6
5	0.456E+06	0.436E+06	0.227E+04	0.113E+06	26.0
6	0.322E+06	0.292E+06	0.317E+04	0.800E+05	27.4
7	0.895E+05	0.723E+05	-0.785E+03	0.205E+05	28.4
8	0.840E+05	0.705E+05	0.216E+04	0.198E+05	28.1
9	0.995E+05	0.968E+05	0.764E+04	0.324E+05	33.5
10	0.301E+05	0.335E+05	0.565E+04	0.149E+05	44.5
11	0.281E+06	0.348E+06	0.674E+05	0.179E+06	51.5

TERMINAL AGE STRUCTURE OF FISHING MORTALITY RATE

Age	MLE	Average of bootstraps	Bias	Std. Error	% CV
0	0.383E-02	0.439E-02	0.535E-03	0.228E-02	52.0
1	0.978E-02	0.120E-01	0.263E-02	0.727E-02	60.4
2	0.154E+00	0.183E+00	0.320E-01	0.103E+00	56.3
3	0.194E+00	0.212E+00	0.118E-01	0.585E-01	27.6
4	0.231E+00	0.253E+00	0.119E-01	0.599E-01	23.7
5	0.359E+00	0.409E+00	0.167E-01	0.934E-01	22.9
6	0.252E+00	0.322E+00	0.212E-01	0.796E-01	24.7
7	0.247E+00	0.305E+00	0.906E-02	0.733E-01	24.0
8	0.358E+00	0.393E+00	0.846E-03	0.102E+00	25.9
9	0.190E+00	0.196E+00	-0.810E-02	0.637E-01	32.5
10	0.156E+00	0.152E+00	-0.410E-02	0.567E-01	37.4
11	0.156E+00	0.152E+00	-0.410E-02	0.567E-01	37.4

CATCHABILITY COEFFICIENTS

Index	MLE	Average of bootstraps	Bias	Std. Error	% CV
NC_TT	0.497E-07	0.501E-07	-0.209E-08	0.677E-08	13.5
MRFSS_NoMix	0.242E-06	0.235E-06	-0.466E-07	0.279E-07	11.9
HB_NoMix	0.349E-06	0.342E-06	-0.379E-07	0.356E-07	10.4
SEAMAP Trawl	0.335E-06	0.337E-06	-0.455E-07	0.470E-07	13.9

Table 3.34. Final values for estimated parameters of the Gulf "base runs".

TERMINAL AGE STRUCTURE OF POPULATION ABUNDANCE

Age	MLE	Average of bootstraps	Bias	Std. Error	% CV
1	0.687E+07	0.779E+07	0.159E+07	0.406E+07	52.2
2	0.589E+07	0.631E+07	0.118E+07	0.264E+07	41.9
3	0.495E+07	0.561E+07	0.760E+06	0.170E+07	30.3
4	0.204E+07	0.183E+07	0.249E+06	0.601E+06	32.8
5	0.817E+06	0.961E+06	0.635E+05	0.234E+06	24.3
6	0.478E+06	0.511E+06	0.402E+05	0.121E+06	23.7
7	0.277E+06	0.301E+06	0.261E+05	0.657E+05	21.8
8	0.162E+06	0.181E+06	0.236E+05	0.452E+05	25.0
9	0.114E+06	0.132E+06	0.233E+05	0.446E+05	33.8
10	0.150E+06	0.129E+06	0.166E+05	0.426E+05	32.9
11	0.387E+06	0.261E+06	0.254E+05	0.983E+05	37.7

TERMINAL AGE STRUCTURE OF FISHING MORTALITY RATE

Age	MLE	Average of bootstraps	Bias	Std. Error	% CV
0	0.853E-01	0.947E-01	0.634E-03	0.478E-01	50.4
1	0.296E-02	0.327E-02	-0.135E-03	0.140E-02	42.9
2	0.313E-01	0.301E-01	-0.184E-02	0.888E-02	29.5
3	0.853E-01	0.104E+00	-0.397E-02	0.357E-01	34.2
4	0.160E+00	0.145E+00	-0.170E-02	0.340E-01	23.4
5	0.185E+00	0.183E+00	-0.509E-02	0.405E-01	22.2
6	0.176E+00	0.170E+00	-0.727E-02	0.355E-01	21.0
7	0.216E+00	0.205E+00	-0.162E-01	0.457E-01	22.3
8	0.203E+00	0.196E+00	-0.181E-01	0.575E-01	29.4
9	0.973E-01	0.123E+00	-0.460E-02	0.385E-01	31.3
10	0.862E-01	0.141E+00	0.337E-02	0.526E-01	37.2
11	0.862E-01	0.141E+00	0.337E-02	0.526E-01	37.2

CATCHABILITY COEFFICIENTS

Index	MLE	Average of bootstraps	Bias	Std. Error	% CV
COM_NoMix	0.532E-07	0.600E-07	-0.366E-08	0.768E-08	12.8
MRFSS_NoMix	0.183E-06	0.203E-06	-0.130E-07	0.210E-07	10.3
HB_NoMix	0.258E-06	0.270E-06	-0.238E-07	0.271E-07	10.0
SEAMAP GF	0.296E-06	0.271E-06	-0.603E-07	0.373E-07	13.8
SEAMAP ICH	0.461E-06	0.488E-06	-0.574E-07	0.612E-07	12.5

3.2.2.3. Stock Abundance and Recruitment

The annual estimates of number-at-age are tabulated in **Tables 3.35 and 3.36**, and in **Figure 3.10**. The abundance of king mackerel Age 1+ has declined in the Atlantic region. In the Gulf, numbers of Age 1+ king mackerel increased slowly between 1980 and 2003, then increased rapidly.

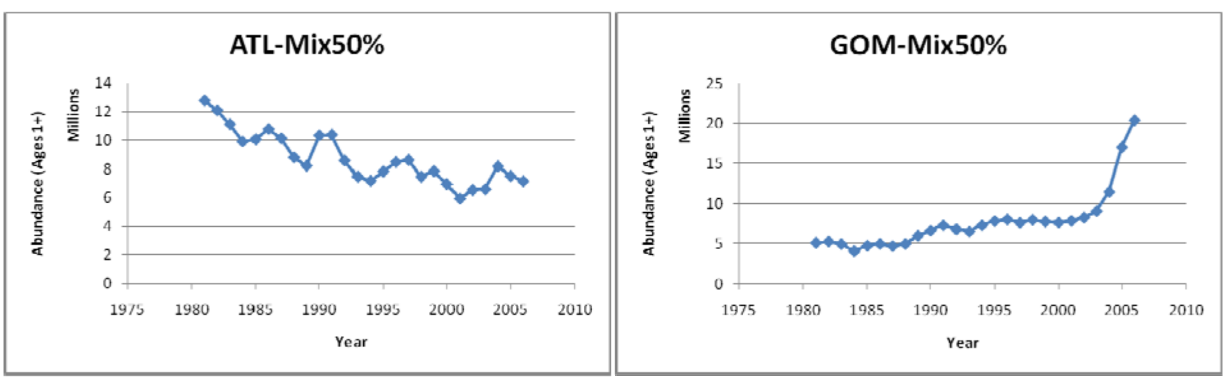


Figure 3.10. Annual trend in abundance (number of fish Ages 1+) for base models.

In the Atlantic, estimated recruitment at age-0 varied without obvious trend, ranging from 2.2 million in 2000 to 8.6 million in 1989 (**Figure 3.11**). In the Gulf, recruitment at age-0 has varied substantially, ranging from 2.0 million in 1983 to 22 million in 2004 (**Figure 3.11**). During recent years recruitment has been quite high, averaging 19 million since 2003. These large recruitment estimates are likely driven by the steep increase in the Shrimp Bycatch Index which indexes the abundance of Age-0 king mackerel and has increased more than 5-fold since the early 1980s.

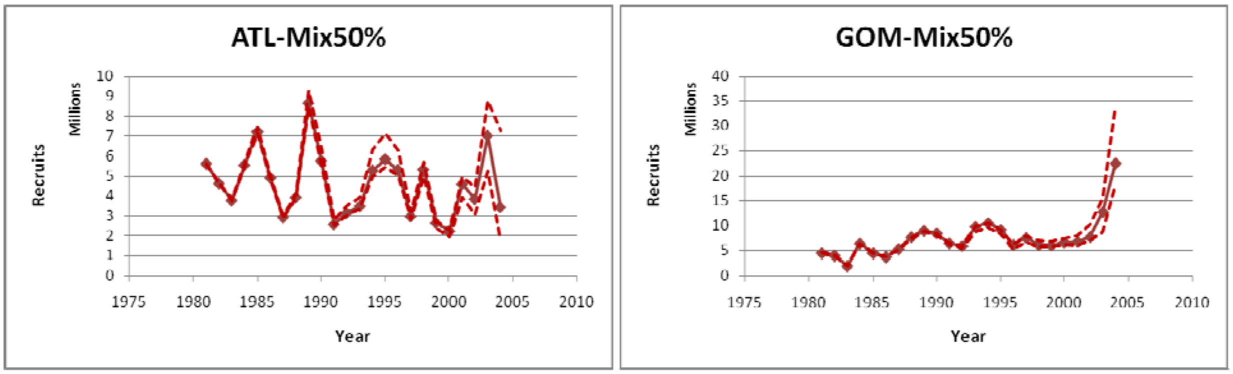


Figure 3.11. Annual trend in recruitment (Age-0) for base models. Upper and lower 80% confidence intervals are indicated with dashed lines. ***Recruitment estimates for 2005 and 2006 are not shown since they are replaced in the VPA with values from the S-R relationship.***

Table 3.35. Number at age for the Atlantic "base model".

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
1981	5593383	2710452	3945190	2173141	1093596	754460	237837	1062496	106668	463557	92158	170766
1982	4610921	2855598	2063235	3082396	1339185	583719	486828	132819	884993	86060	393307	203455
1983	3758930	2330487	2134125	1604767	2277697	755897	334568	349114	79698	741489	65356	468433
1984	5524883	1874371	1589071	1547356	1103753	1688776	524720	192824	280115	63627	631709	424253
1985	7178154	2779446	1398465	1244368	1036952	687809	1286843	354272	144224	236399	50989	854626
1986	4902068	3504362	2091859	1001742	868384	554264	389261	1029155	282696	114614	195982	761223
1987	2906274	2502871	2585807	1422831	722288	548678	392264	275089	722361	208550	73357	697206
1988	3904312	1484200	1735818	1887202	1048715	518921	392211	268875	210486	540901	153414	571471
1989	8626111	1993138	1130185	1224445	1302042	721843	391503	271393	171116	156598	385333	476405
1990	5733484	4389240	1476980	817067	883112	963861	516917	271615	197333	117028	116009	603318
1991	2551245	2883301	3252968	1042717	580591	627492	718353	365836	198933	145592	71748	512524
1992	3119440	1284918	2162356	2287046	694141	397277	425331	501202	242101	124021	100137	377877
1993	3466691	1572122	958451	1508708	1530777	460031	257054	293639	355927	168847	82129	290618
1994	5263048	1755730	1171486	701281	1112825	1137419	337725	182499	201440	247797	115455	232732
1995	5812846	2673228	1307443	802743	499522	810315	836194	224480	127049	142919	175045	232194
1996	5294990	2940602	1983040	885108	550078	336857	602139	591216	157787	81008	84980	274413
1997	2953842	2662584	2218917	1328687	582959	351981	221501	450156	413507	98881	47966	252888
1998	5305202	1497574	1970197	1529698	895899	371309	230461	142752	311425	278275	57133	192155
1999	2622388	2674857	1131931	1402722	1036567	572242	227080	150576	93855	215569	184322	168971
2000	2207926	1316909	2007590	790244	1016283	707397	396191	151817	106519	64135	159019	260003
2001	4579475	1114774	1004182	1351954	515916	671633	490218	286229	108583	80995	42100	286790
2002	3822839	2333841	850072	732527	966023	322087	454663	331518	206164	81650	60548	222620
2003	6980102	1946049	1756362	538576	506540	663052	206377	322012	246947	152143	60608	210345
2004	3418515	3554155	1489177	1217288	350712	323221	425297	121721	208387	175524	115965	202491
2005	***	1740207	2707911	1013260	814041	216229	194471	253856	70781	134384	129422	243099
2006	***	1848046	1335971	1885841	691134	549091	136525	126881	167242	42702	89983	292357

*** The 2005 and 2006 Age-0 estimates were replaced in the VPA with values from the S-R relationship.

Table 3.36. Number at age for the Gulf "base model".

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
1981	4488421	1326707	862115	1012233	737862	189403	121000	101682	75045	27834	151538	484701
1982	4006059	1718337	994357	647929	618066	426837	111861	75373	64971	54498	19798	522652
1983	1962367	1703323	1258927	621035	382525	317334	216502	33821	46577	38485	27260	294593
1984	6394093	604404	1215392	820788	404021	287281	220621	151888	22346	30745	28054	257270
1985	4474755	1996126	441666	902268	461410	214209	203466	138417	103352	14394	25022	224999
1986	3719810	1603043	1496844	297096	638830	310222	100768	140052	103711	69546	7595	194926
1987	5269426	1200873	1186903	989739	166530	487886	205703	47883	105494	84183	52239	158017
1988	7701647	1498560	826940	862627	763978	112391	373916	155072	32641	84192	67638	170265
1989	8990647	2481495	1098694	563006	612272	563408	64142	247417	102270	21837	58433	158939
1990	8475110	2418753	1780382	718353	378202	434115	415564	42094	185371	75753	14312	163212
1991	6435513	2586881	1748102	1252211	481897	241869	324876	309862	28394	138097	55961	132270
1992	5871846	1697331	1808686	1159366	889302	328406	162852	244201	246588	19711	98354	143820
1993	9813684	1781897	1233606	1241854	766600	630409	220835	92434	184473	175599	8136	167084
1994	10521984	2752917	1302542	839050	859690	502194	461970	150083	53928	132285	135816	116007
1995	9148162	2875654	1983355	885352	561166	553584	306544	320245	87718	22894	93125	145963
1996	6130664	2491653	2144758	1402075	564447	363708	396321	193173	238512	57447	12114	177602
1997	7539743	1958354	1818770	1468921	983471	380854	250964	295752	129224	174552	36578	120981
1998	6087322	2627504	1441833	1291482	995346	706370	248755	166968	204817	81608	127200	99784
1999	5994903	2054558	1947002	1026782	898030	657827	516088	169897	116953	155726	50241	177271
2000	6594913	2000583	1522359	1414432	738635	625314	460417	401390	116753	80231	110483	180162
2001	6753330	2363221	1465419	1075858	976326	512469	456207	355291	304087	89763	54700	220584
2002	7720627	2634666	1754601	1021070	730993	688095	358717	334694	257116	231187	68403	201334
2003	12770877	3169744	1941776	1196309	701882	493724	499303	261116	251405	187830	180387	202104
2004	22548437	4928554	2386271	1389228	816777	483578	344405	360335	194584	187654	141785	293337
2005	***	8595460	3718014	1669051	997082	569087	348573	246462	266396	153057	137119	349969
2006	***	7775395	6514601	2771612	1180443	700328	398256	241237	167461	196022	118280	378515

*** The 2005 and 2006 Age-0 estimates were replaced in the VPA with values from the S-R relationship.

3.2.2.4. Spawning Stock Biomass

According to the base models, the spawning stock in the Atlantic decreased about 45% since 1981, while in the Gulf, the spawning stock increased roughly 2-fold from 1985 to 2001, then increased steeply after 2001, mostly due to larger than average recruitment during that time (**Figure 3.12 and Table 3.36)**. Results were computed with and without a recruitment patch.

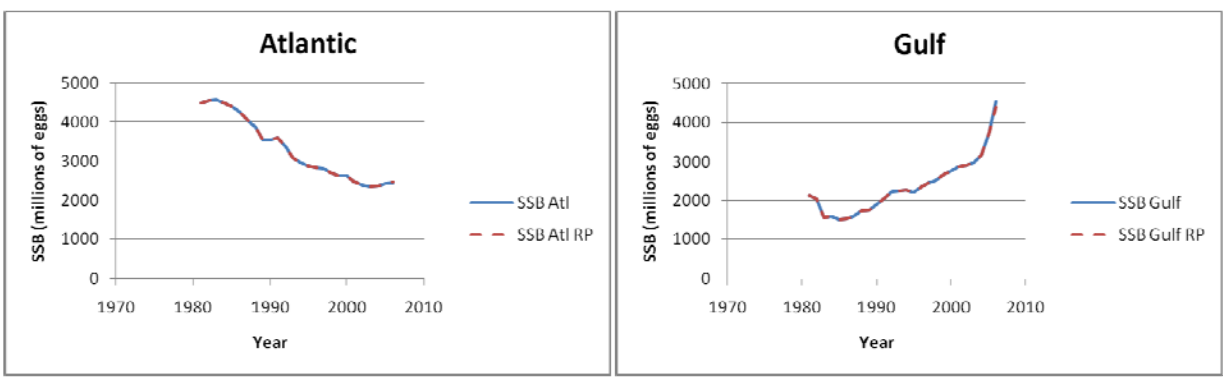
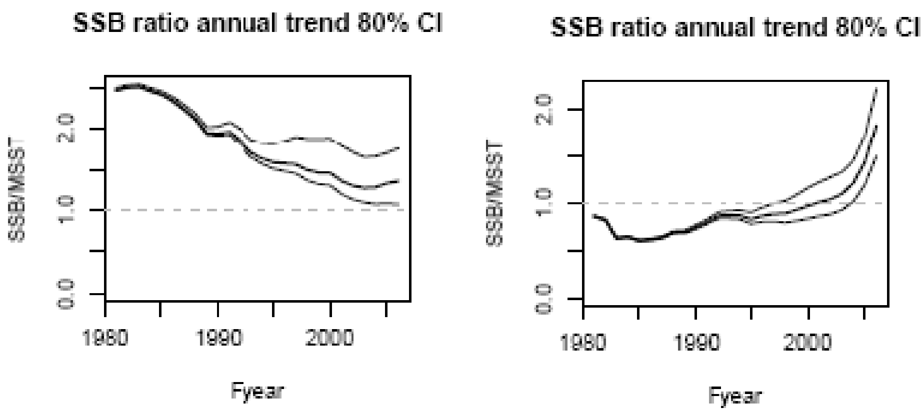


Figure 3.12. Annual trend in spawning stock (millions of eggs) for base models. Results were computed with and without application of a recruitment patch (RP).

Spawning stock trajectories, as a function of the management reference MSST (where MSST = (1-M) * SSB_{SPR30}. and M = 0.1603 in the Atlantic and 0.1738 in the Gulf of Mexico) are shown in (**Figure 3.13 and Table 3.37)**. The replacement of recent recruitment estimates has little effect on SSB-based reference points. Regardless of the use of the recruitment patch, in the Atlantic SSB/MSST declined during the time series from 2.4 in 1981 to 1.3 in 2006, and in the Gulf, SSB/MSST generally increased during the time series, from 0.87 in 1981 to about 1.8 in 2006. According to the deterministic results, the Atlantic and Gulf migratory stocks were not overfished as of 2006, although the stock had been overfished as recently as 1991 in the Gulf.

Use 2005 and 2006 Recruitment:

Atlantic **Gulf**



Replace 2005 and 2006 Recruitment from S-R Relationship:

Atlantic **Gulf**

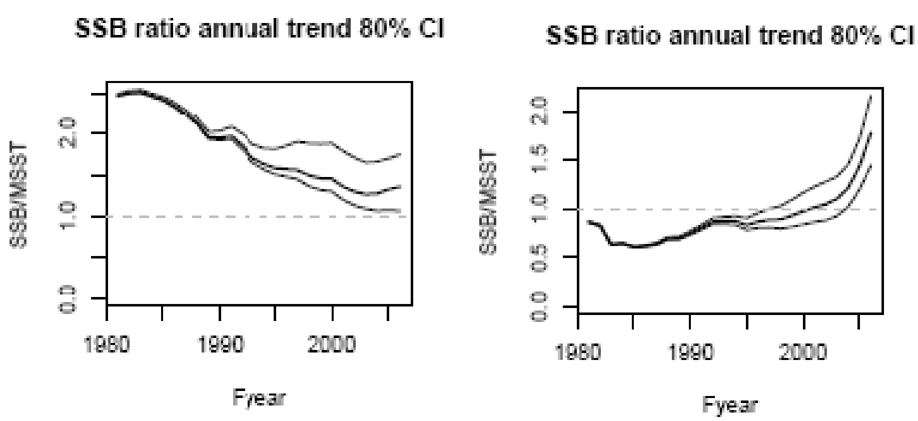


Figure 3.13. Annual trend in SSB/MSST for base models with upper and lower 80% confidence intervals. Upper panels used the 2005 and 2006 recruitment estimates. Lower panels used replacement of 2005 and 2006 recruitment estimates from S-R relationship.

Table 3.37. Spawning stock (millions of eggs) and SSB/MSST for the Atlantic and Gulf “base models”. Results were computed with and without application of a recruitment patch (RP: replacing 2005 and 2006 recruitment with estimates from the S-R relationship).

Year	SSB ATL	SSB ATL Rec Patch	SSB/MSST ATL	SSB/MSST ATL Rec. Patch	Year	SSB Gulf	SSB Gulf Rec Patch	SSB/MSST Gulf	SSB/MSST Gulf Rec. Patch
1981	4508	4508	2.47	2.47	1981	2123	2123	0.87	0.87
1982	4568	4568	2.50	2.50	1982	2036	2036	0.83	0.83
1983	4587	4587	2.51	2.51	1983	1555	1555	0.64	0.64
1984	4498	4498	2.46	2.46	1984	1591	1591	0.65	0.65
1985	4418	4418	2.42	2.42	1985	1502	1502	0.61	0.61
1986	4275	4275	2.34	2.34	1986	1533	1533	0.63	0.63
1987	4086	4086	2.24	2.24	1987	1591	1591	0.65	0.65
1988	3873	3873	2.12	2.12	1988	1732	1732	0.71	0.71
1989	3555	3555	1.95	1.95	1989	1749	1749	0.72	0.71
1990	3545	3545	1.94	1.94	1990	1887	1887	0.77	0.77
1991	3580	3580	1.96	1.96	1991	2042	2042	0.84	0.83
1992	3369	3369	1.84	1.84	1992	2217	2217	0.91	0.91
1993	3098	3098	1.70	1.70	1993	2249	2249	0.92	0.92
1994	2962	2962	1.62	1.62	1994	2269	2269	0.93	0.93
1995	2873	2873	1.57	1.57	1995	2215	2215	0.91	0.91
1996	2847	2847	1.56	1.56	1996	2346	2346	0.96	0.96
1997	2824	2824	1.55	1.55	1997	2451	2451	1.00	1.00
1998	2701	2701	1.48	1.48	1998	2516	2516	1.03	1.03
1999	2641	2641	1.45	1.45	1999	2657	2657	1.09	1.09
2000	2640	2640	1.45	1.44	2000	2771	2771	1.13	1.13
2001	2476	2476	1.36	1.35	2001	2864	2864	1.17	1.17
2002	2377	2377	1.30	1.30	2002	2904	2904	1.19	1.19
2003	2341	2341	1.28	1.28	2003	2979	2979	1.22	1.22
2004	2365	2365	1.29	1.29	2004	3184	3184	1.30	1.30
2005	2433	2433	1.33	1.33	2005	3690	3690	1.51	1.51
2006	2443	2457	1.34	1.34	2006	4543	4398	1.86	1.80

3.2.2.5. Fishery Selectivity

For the base models, fleet/index selectivity-at-age was estimated using the partial catches (fleet specific catch-at-age) fit using the Butterworth and Geromont (1999) method (**Figure 3.14 and Table 3.38**). This approach computes an average, constant selectivity pattern for the entire time period. It is important to note that the shrimp bycatch indices (SEAMAP) were assigned a fixed selectivity equal to 1.0 for Age-0 and 0.0 for all other ages. Also, the SEAMAP

Ichthyoplankton survey was used to index SSB, and assigned a fixed selectivity equal to Maturity*Fecundity-at-age.

According to the VPA “base model” the selectivity of the recreational fleets was generally maximal at ages 2-5. The headboat selectivity declines quickly on older ages, while the MRFSS recreational fishery continues to land (or catch and release) older king mackerel. The commercial selectivity-at-age is similar to the headboat in the Atlantic, with the exception that older fish continue to experience high vulnerability to the Atlantic commercial fleet. In the Gulf, the selectivity of the commercial fleet is relatively low on the youngest ages, maximal on ages 7-8, and continues to be high through Age 11+.

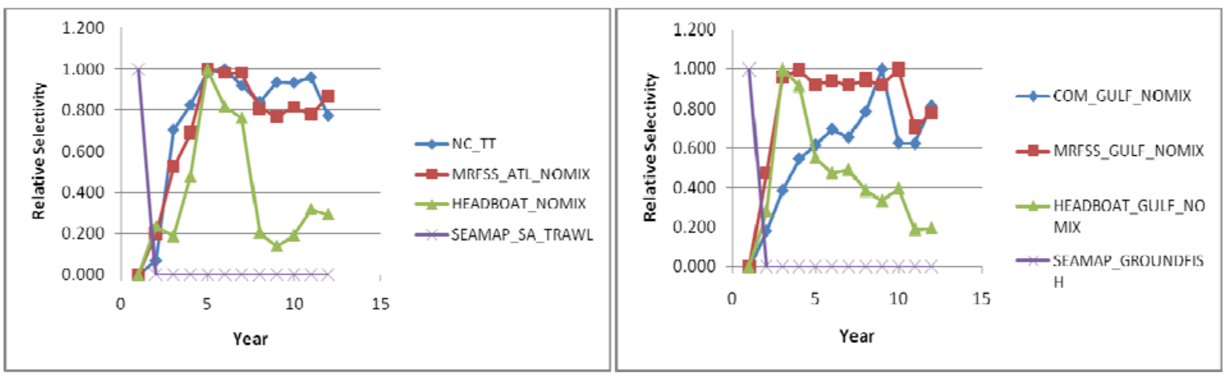


Figure 3.14. Fleet/Index selectivity by age for the base models.

Table 3.38. Fleet/Index selectivity by age for the base models.

Region	Fleet/Index	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+
ATL	NC_TT	-	0.069	0.703	0.824	0.983	1.000	0.920	0.841	0.936	0.934	0.960	0.772
	MRFSS_ATL_NOMIX	-	0.200	0.525	0.689	1.000	0.981	0.982	0.807	0.768	0.813	0.779	0.868
	HEADBOAT_NOMIX	-	0.234	0.189	0.479	1.000	0.817	0.762	0.205	0.142	0.192	0.318	0.294
	SEAMAP_SA_TRAWL	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GOM	COM_GULF_NOMIX	-	0.180	0.386	0.547	0.616	0.697	0.655	0.785	1.000	0.627	0.624	0.814
	MRFSS_GULF_NOMIX	-	0.476	0.961	0.995	0.922	0.944	0.917	0.946	0.922	1.000	0.707	0.777
	HEADBOAT_GULF_NOMIX	-	0.284	1.000	0.917	0.552	0.476	0.493	0.387	0.335	0.398	0.191	0.196
	SEAMAP_GROUNDFISH	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SEAMAP_PLANKTON	0.000	0.024	0.141	0.278	0.455	0.661	0.801	0.926	1.041	1.145	1.238	1.524

3.2.2.6. Fishing Mortality

Annual trends in fishing mortality are summarized in **Figure 3.15 and Table 3.39**. Results were computed with and without the use of a "recruitment patch" (defined in previous sections). In the Atlantic, the use of the patch had no discernable effect on the results. The highest estimated fishing mortality rate occurred in 1981 and 1984 (0.44). Since then, fishing mortality has varied without obvious trend.

In the Gulf, the highest fishing mortality occurred in 1982 (1.0). During 1982-1995, apical F varied without obvious trend, ranging from 0.37 to 0.71. This period was followed by several years of constant low fishing morality (0.25) unless the recruitment patch was applied. Application of the patch caused a high apical fishing mortality on Age-0 in 2005 (0.52), because the estimated recruitment in 2005 was reduced without modifying the 2005 shrimp bycatch (composed of Age-0 king mackerel). Since the VPA model must match catch-at-age exactly the recruitment patch, applied in this manner, forces the model to interpret the high shrimp bycatch in 2005 as being due to high fishing mortality rather than high abundance.

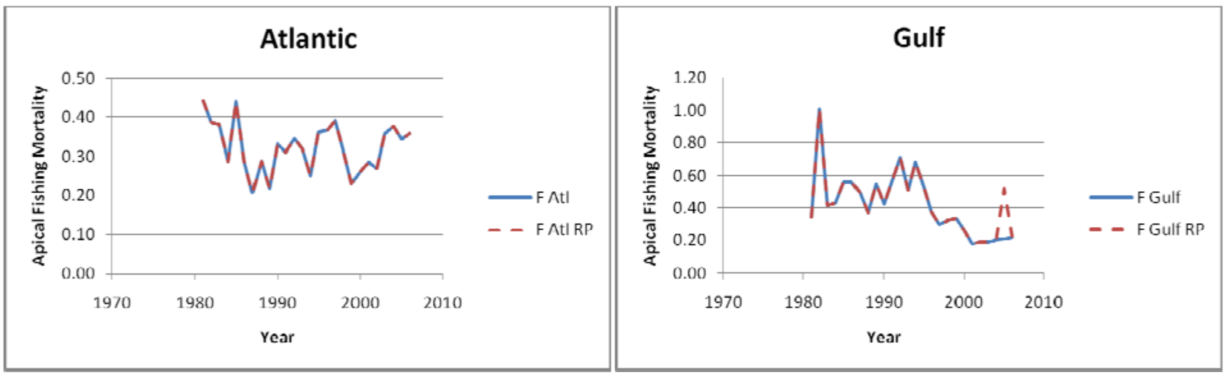


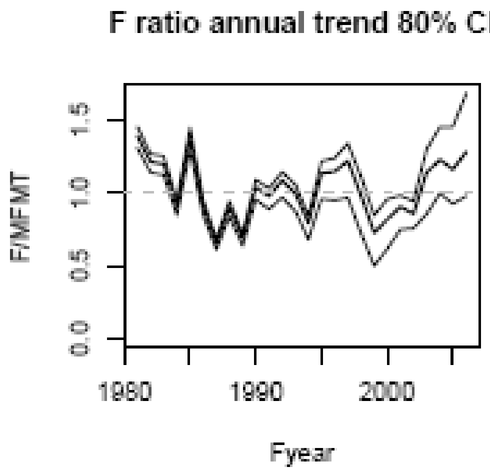
Figure 3.15. Annual trend in apical fishing mortality for base models. Results were computed with and without application of a recruitment patch (RP).

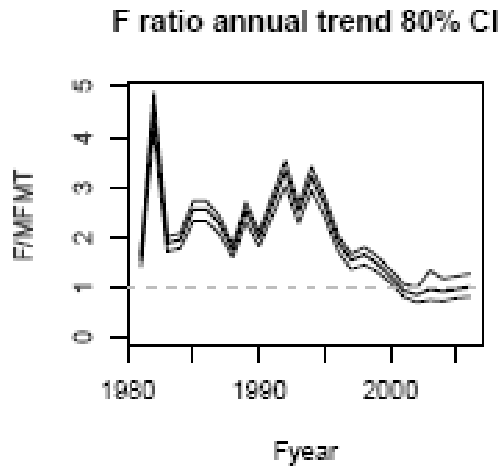
Fishing mortality trajectories as a function of the management reference MFMT (MFMT = F_{SPR30}) are shown in **Figure 3.16 and Table 3.39.** In the Atlantic, F/MFMT has varied without trend during the time series from roughly 1.4 in 1981 to 1.2 in 2006, and MFMT is not sensitive to the application of the recruitment patch.

In the Gulf, the estimate of MFMT was sensitive to the application of the recruitment patch. When the 2005 and 2006 recruitment estimates were used directly, MFMT was equal to 0.22. When a recruitment patch was employed, MFMT increased to 0.27 (**see Section 3.2.2.9; Table 3.43)**. This had important implications for the F/MFMT trajectory in the Gulf (**Figure 3.16**). According to the deterministic results, the Atlantic and Gulf migratory stocks were not experiencing overfishing in 2006 (**Table 3.39**).

Use 2005 and 2006 Recruitment:

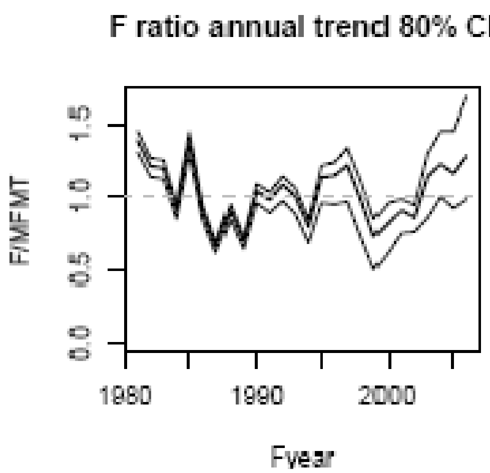
Atlantic | **Gulf**





Replace 2005 and 2006 Recruitment from S-R Relationship:

Atlantic | **Gulf**



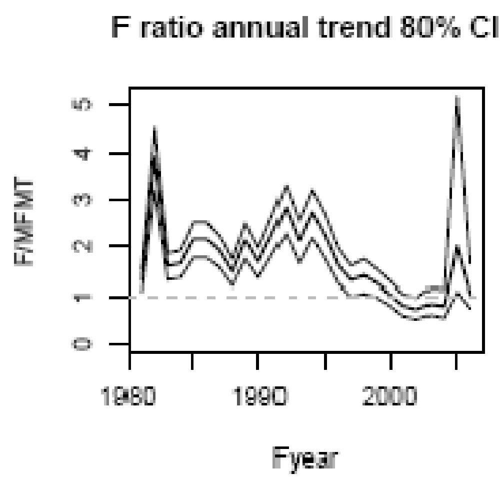


Figure 3.16. Annual trend in F/MFMT for base models with and without application of a recruitment patch (RP). Upper panels used the 2005 and 2006 recruitment estimates. Lower panels used replacement of 2005 and 2006 recruitment estimates from S-R relationship.

Table 3.39. Annual trend in apical fishing mortality for base models. Results were computed with and without application of a recruitment patch (RP).

Year	F ATL	F ATL Rec Patch	F/MFMT ATL	F/MFMT ATL Rec. Patch
1981	0.44	0.44	1.43	1.43
1982	0.39	0.39	1.25	1.25
1983	0.38	0.38	1.24	1.24
1984	0.29	0.29	0.93	0.93
1985	0.44	0.44	1.43	1.43
1986	0.29	0.29	0.93	0.93
1987	0.21	0.21	0.68	0.68
1988	0.29	0.29	0.93	0.93
1989	0.22	0.22	0.71	0.71
1990	0.33	0.33	1.07	1.07
1991	0.31	0.31	1.01	1.01
1992	0.34	0.34	1.12	1.12
1993	0.32	0.32	1.03	1.03
1994	0.25	0.25	0.82	0.82
1995	0.36	0.36	1.17	1.17
1996	0.37	0.37	1.19	1.19
1997	0.39	0.39	1.27	1.27
1998	0.32	0.32	1.02	1.02
1999	0.23	0.23	0.76	0.76
2000	0.26	0.26	0.85	0.85
2001	0.29	0.29	0.93	0.93
2002	0.27	0.27	0.87	0.87
2003	0.36	0.36	1.16	1.16
2004	0.38	0.38	1.22	1.22
2005	0.34	0.34	1.12	1.12
2006	0.36	0.36	1.16	1.16

Year	F Gulf	F Gulf Rec Patch	F/MFMT Gulf	F/MFMT Gulf Rec. Patch
1981	0.34	0.34	1.55	1.27
1982	1.01	1.01	4.60	3.75
1983	0.41	0.41	1.89	1.54
1984	0.43	0.43	1.95	1.59
1985	0.56	0.56	2.55	2.07
1986	0.56	0.56	2.54	2.07
1987	0.49	0.49	2.25	1.83
1988	0.37	0.37	1.68	1.37
1989	0.55	0.55	2.50	2.04
1990	0.42	0.42	1.93	1.57
1991	0.57	0.57	2.59	2.11
1992	0.71	0.71	3.25	2.65
1993	0.51	0.51	2.31	1.88
1994	0.68	0.68	3.10	2.53
1995	0.54	0.54	2.45	1.99
1996	0.38	0.38	1.72	1.40
1997	0.29	0.29	1.34	1.09
1998	0.32	0.32	1.47	1.20
1999	0.33	0.33	1.52	1.24
2000	0.26	0.26	1.19	0.97
2001	0.18	0.18	0.81	0.66
2002	0.19	0.19	0.85	0.69
2003	0.19	0.19	0.86	0.70
2004	0.20	0.20	0.91	0.74
2005	0.20	0.52	0.93	1.92
2006	0.22	0.22	0.98	0.82

The estimated terminal year (2006) fishing mortality rates-at-age for the base models are shown in **Figure 3.17**. These parameters were estimated for ages 0-10. The plus group (11+) terminal F was fixed at the estimated value for age 10. The values are also tabulated in Section *3.2.2.2.*

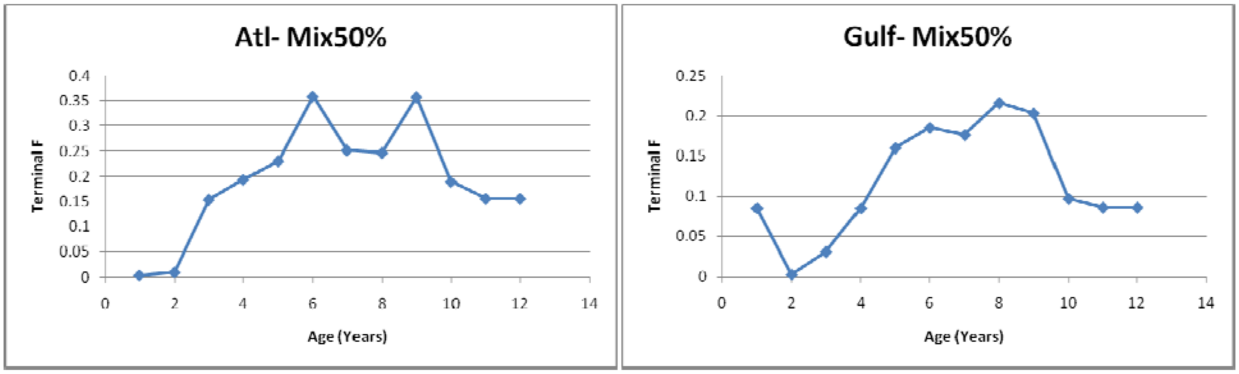


Figure 3.17. Terminal year (2006) fishing mortality-at-age for base models.

In addition to the discussion above about the impact that using the "recruitment patch" has on the estimation of F/MFMT, SEDAR 16 should take into account possible inconsistencies in how current selectivity and current F are defined (see **Appendix 1**).

3.2.2.7. Stock-Recruitment Parameters

As per the instructions of the SEDAR16 AW panel, the stock recruitment relationship was modeled using a Berverton-Holt S-R function with an assumption of high steepness (0.95). Maximum recruitment was set equal to the geometric mean of VPA estimated recruits over the years for which indices of stock and recruitment were both available (1981-2004 GOM and 1989-2004 ATL) (**Figure 3.18**). The parameters of the S-R relationship are tabulated in **Table 3.40**.

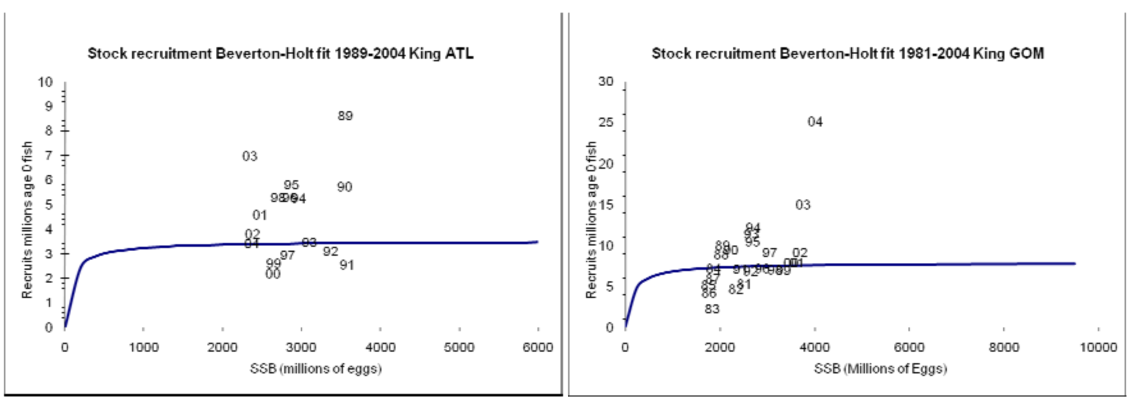


Figure 3.18. Beverton and Holt S-R functions fit to the results of the base models.

Table 3.40. Stock recruitment parameters for the base models.

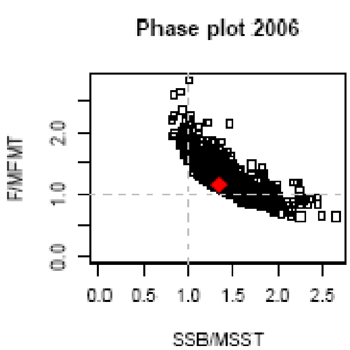
Region	Steepness	A (R0)	B (S0)	CV
ATL	Fixed at 0.95	3.46E+06	6453	0.40
GULF	Fixed at 0.95	7.78E+06	11721	0.52

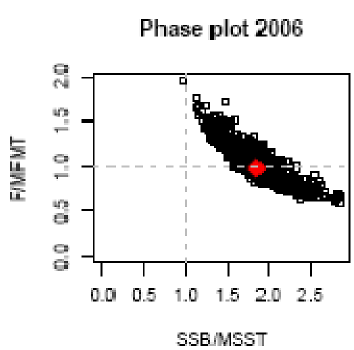
3.2.2.8. Evaluation of Uncertainty

To evaluate model uncertainty, 1000 bootstraps were run using the index residuals for both base and sensitivity models. The results were used to construct “phase plots” of the 2006 stock status (**Figure 3.19**). The x-axis indicates 2006 spawning stock biomass as a function of the management benchmark MSST (MSST = (1-M) *SSB_{SPR30}). Values less than MSST indicate that the population is overfished. The y-axis indicates the 2006 fishing mortality as a function of the management benchmark MFMT (= F_{SPR30}). Values greater than 1.0 suggest the population is experiencing overfishing. Phase plots were constructed for the base model with and without the use of a recruitment patch.

Use 2005 and 2006 Recruitment:

ATL **GULF**





Replace 2005 and 2006 Recruitment from S-R Relationship:

ATL **GULF**

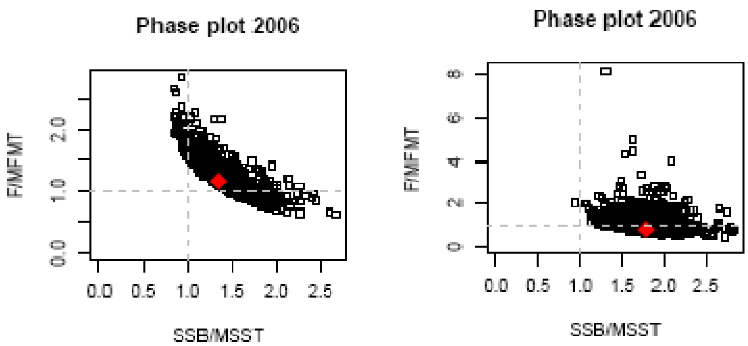


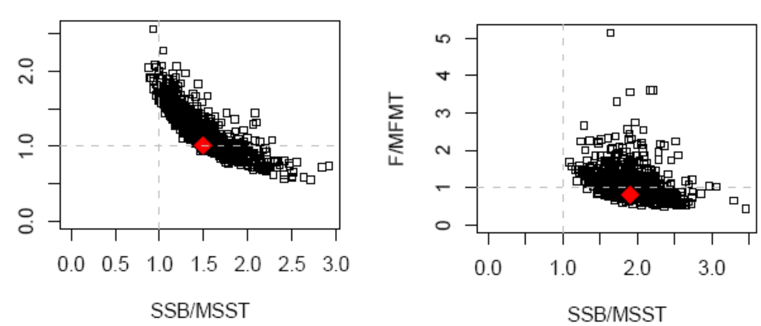
Figure 3.19. Phase plots of 2006 stock status for the base cases with and without application of a recruitment patch (RP). Upper panels used the 2005 and 2006 recruitment estimates. Lower panels used replacement of 2005 and 2006 recruitment estimates from S-R relationship. The red diamond is the deterministic result, black squares are bootstrap results.

In addition to the base runs, bootstraps analyses were completed for three sensitivity runs (**Figure 3.20**). Following the advice of the SEDAR16 AW panel, all sensitivity runs replaced the 2005 and 2006 recruitments with estimates from the S-R relationship. Other model inputs and settings were identical to the base case except that:

1. Sensitivity 1 was intended to examine the influence of the “Status Quo – Mixing” assumption (e.g. 100% of winter landings in mixing zone assigned to Gulf)
2. For Sensitivity 2, indices of abundance were equally weighted and each index CV was set equal to 1.0 (annual estimates of abundance weighted equally).
3. For Sensitivity 3, variance scaling parameters were estimated for each index.

ATL **GULF**

A)



B)

C)

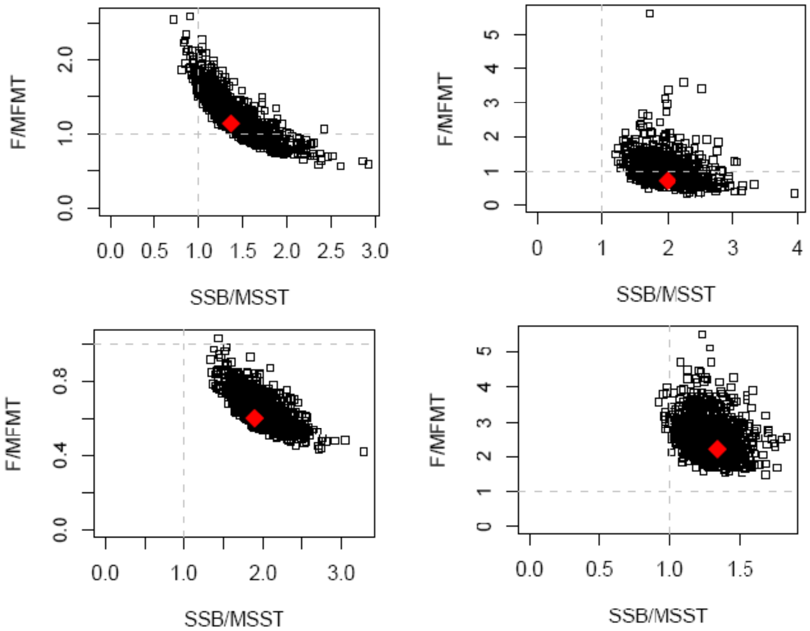


Figure 3.20. Phase plots of 2006 stock status from the sensitivity runs **A)** Status Quo Mixing, **B)** Estimate Variance Scalars and **C)** Equally Weighted Indices sensitivity runs. The red diamond is the deterministic result, black squares are bootstrap results. All sensitivity runs replaced 2005 and 2006 recruitments with values from the S-R relationship.

The bootstrap results were used to estimate the probability of an overfished condition (SSB_{2006} < MSST) and current overfishing (F_{2006} > MFMT). These results are summarized in **Table 3.41**. For the base runs, probabilities were calculated with and without the application of the recruitments patch. Following the advice of the SEDAR 16 AW panel, all sensitivity runs used the recruitment patch.

Table 3.41. Probability that SSB_{2006} < MSST or F_{2006} > MFMT. The

Region	Model	Prob. SSB_{2006} < MSST (Overfished)	Prob. F_{2006} < MFMT (Overfishing)
Atl	Base – Use 2005 and 2006 Recruitment	4.1%	87.6%
	Base – with Recruitment Patch	4.7%	87.7%
	Status Quo Mixing	1.8%	76.5%
	Equal Weight Indices	4.0%	78.3%
	Estimate Variance Scalars	0.0%	0.1%
Gulf	Base – Use 2005 and 2006 Recruitment	0.1%	49.2%
	Base - with Recruitment Patch	0.1%	56.0%
	Status Quo Mixing	0.0%	47.0%
	Equal Weight Indices	0.0%	39.9%
	Estimate Variance Scalars	1.0%	100%

3.2.2.9. Benchmarks / Reference Points / ABC values

The benchmarks and reference points for the base and sensitivity runs are summarized in **Figure 3.21** and **Tables 3.42 – 3.47**. For the base runs, benchmarks and reference points were calculated with and without the application of the recruitments patch. Following the advice of the SEDAR 16 AW panel, all sensitivity runs used the recruitment patch. To date, no ABC values have been provided to the SEDAR 16 AW or RW panels.

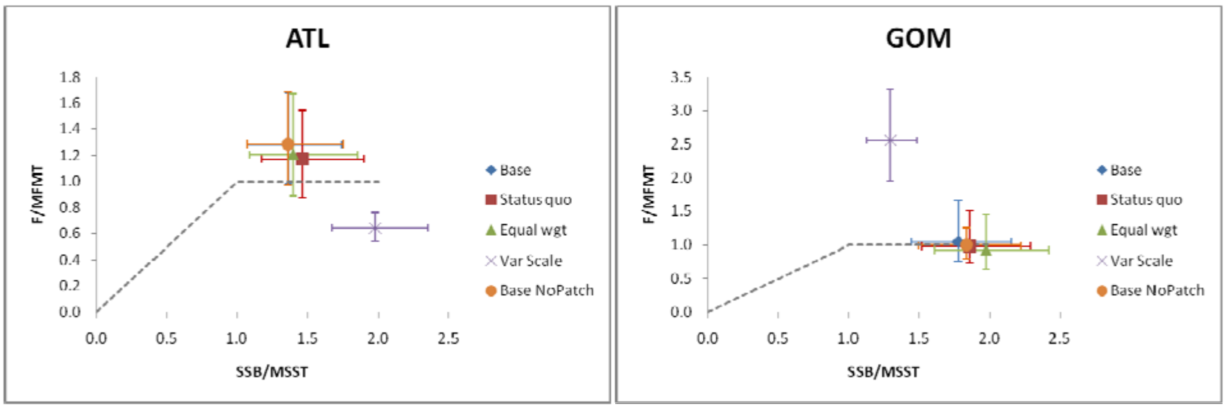


Figure 3.21. Phase plot showing 2006 stock status for base runs and sensitivity analyses. The errors bars indicate the 10th and 90th percentiles.

Table 3.42. Benchmarks / Reference Points for the Atlantic base and sensitivity runs.

ATL	Base Run (50-50% Mixing) - Use 2005 and 2006 recruitment estimates.			Base Run - (50-50% Mixing) Replace 2005 and 2006 recruitments with estimates from the S-R relationship.			Sensitivity Run - Status Quo Mixing (100% of winter landings in Mixing Zone assigned to Gulf)			Sensitivity Run - Equal Weight Indices			Sensitivity Run - Estimate Variance Scalars		
MEASURE	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI
F SPR30	0.31	0.30	0.34	0.31	0.30	0.34	0.34	0.34	0.37	0.30	0.30	0.34	0.31	0.30	0.34
F SPR40	0.21	0.21	0.24	0.21	0.21	0.24	0.23	0.23	0.26	0.21	0.20	0.24	0.21	0.21	0.24
F 65% FSPR30	0.20	-	-	0.20	-	-	0.22	-	-	0.20	-	-	0.20	-	-
F 75% FSPR30	0.23	-	-	0.23	-	-	0.26	-	-	0.23	-	-	0.23	-	-
F 85% FSPR30	0.26	-	-	0.26	-	-	0.29	-	-	0.26	-	-	0.26	-	-
Y @ SPR30 (LBS)	8.88E+06	8.62E+06	8.98E+06	8.88E+06	8.62E+06	8.98E+06	7.41E+06	7.26E+06	7.51E+06	8.94E+06	8.72E+06	9.08E+06	1.07E+07	1.05E+07	1.08E+07
S/R at F30	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
S/R at F40	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
S/R at 65% FSPR30	0.74	-	-	0.74	-	-	0.74	-	-	0.74	-	-	0.76	-	-
S/R at 75% FSPR30	0.67	-	-	0.67	-	-	0.67	-	-	0.67	-	-	0.68	-	-
S/R at 85% FSPR30	0.61	-	-	0.54	-	-	0.54	-	-	0.54	-	-	0.54	-	-
SSB at F30	2175	2172	2177	2176	2172	2177	1806	1804	1807	2189	2187	2192	2688	2686	2692
SSB at F40	2928	2928	2936	2929	2928	2936	2438	2432	2438	2948	2948	2956	3624	3621	3631
SSB at 65% FSPR30	3043	-	-	3043	-	-	2507	-	-	3061	-	-	3834	-	-
SSB at 75% FSPR30	2743	-	-	2743	-	-	2260	-	-	2760	-	-	3440	-	-
SSB at 85% FSPR30	2490	-	-	2180	-	-	1811	-	-	2195	-	-	2694	-	-
Y/R at F30	1.00	0.97	1.01	1.00	0.97	1.01	1.00	0.98	1.01	1.00	0.97	1.01	0.97	0.95	0.98
Y/R at F40	0.89	0.86	0.91	0.89	0.86	0.91	0.90	0.87	0.91	0.89	0.86	0.91	0.87	0.85	0.88
Y/R at 65% FSPR30	0.88	-	-	0.88	-	-	0.88	-	-	0.88	-	-	0.84	-	-
Y/R at 75% FSPR30	0.92	-	-	0.92	-	-	0.93	-	-	0.92	-	-	0.89	-	-
Y/R at 85% FSPR30	0.96	-	-	0.96	-	-	0.96	-	-	0.96	-	-	0.93	-	-
M	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
F2006	0.36	0.31	0.53	0.36	0.31	0.53	0.34	0.31	0.55	0.35	0.28	0.53	0.19	0.17	0.25
F Current	0.30	0.27	0.38	0.30	0.27	0.38	0.29	0.28	0.39	0.29	0.25	0.38	0.19	0.17	0.23
SSB 2006	2443.0	1951.0	3203.0	2457.0	1958.0	3183.0	2267.0	1768.0	2873.0	2513.0	1995.0	3403.0	4283.0	3775.0	5315.0
SSB2006/SSBSPR30	1.12	0.90	1.47	1.13	0.90	1.46	1.26	0.98	1.59	1.15	0.91	1.55	1.59	1.41	1.97
F2006/FSPR30	1.16	1.02	1.59	1.16	1.02	1.59	1.01	0.92	1.48	1.14	0.94	1.56	0.60	0.57	0.73
MFMT	0.31	0.30	0.34	0.31	0.30	0.34	0.34	0.34	0.37	0.30	0.30	0.34	0.31	0.30	0.34
MSST	1820.6	1817.9	1821.9	1821.7	1817.9	1821.9	1511.9	1509.9	1512.8	1832.4	1830.3	1834.3	2250.0	2247.9	2253.2

Table 3.43. Benchmarks / Reference Points for the Gulf base and sensitivity runs.

GULF	Base Run (50-50% Mixing) - Use 2005 and 2006 recruitment estimates.			Base Run - (50-50% Mixing) Replace 2005 and 2006 recruitments with estimates from the S-R relationship.			Sensitivity Run - Status Quo Mixing (100% of winter landings in Mixing Zone assigned to Gulf)			Sensitivity Run - Equal Weight Indices			Sensitivity Run - Estimate Variance Scalars		
MEASURE	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI	Determ. Run	LOWER 80% CI	UPPER 80% CI
F SPR30	0.22	0.21	0.24	0.27	0.22	0.31	0.24	0.21	0.28	0.32	0.26	0.38	0.29	0.25	0.34
F SPR40	0.16	0.15	0.17	0.19	0.16	0.23	0.18	0.15	0.20	0.23	0.19	0.28	0.21	0.19	0.25
F 65% FSPR30	0.14	-	-	0.17	-	-	0.16	-	-	0.21	-	-	0.19	-	-
F 75% FSPR30	0.16	-	-	0.20	-	-	0.18	-	-	0.24	-	-	0.22	-	-
F 85% FSPR30	0.19	-	-	0.23	-	-	0.21	-	-	0.27	-	-	0.24	-	-
Y @ SPR30 (LBS)	1.01E+07	9.97E+06	1.07E+07	9.39E+06	9.29E+06	1.00E+07	1.11E+07	1.09E+07	1.18E+07	9.16E+06	8.85E+06	9.68E+06	8.04E+06	7.89E+06	8.29E+06
S/R at F30	0.46	0.45	0.46	0.46	0.45	0.46	0.45	0.45	0.46	0.46	0.45	0.46	0.45	0.45	0.46
S/R at F40	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
S/R at 65% FSPR30	0.65	-	-	0.57	-	-	0.58	-	-	0.67	-	-	0.67	-	-
S/R at 75% FSPR30	0.58	-	-	0.51	-	-	0.51	-	-	0.60	-	-	0.60	-	-
S/R at 85% FSPR30	0.45	-	-	0.46	-	-	0.45	-	-	0.45	-	-	0.45	-	-
SSB at F30	2959	2953	2963	2962	2953	2962	3424	3423	3434	3137	3128	3136	2736	2731	2739
SSB at F40	3991	3979	3995	3993	3979	3992	4613	4612	4630	4223	4214	4226	3693	3679	3692
SSB at 65% FSPR30	4280	-	-	3774	-	-	4398	-	-	4677	-	-	4101	-	-
SSB at 75% FSPR30	3830	-	-	3319	-	-	3866	-	-	4160	-	-	3643	-	-
SSB at 85% FSPR30	2959	-	-	2962	-	-	3424	-	-	3137	-	-	2736	-	-
Y/R at F30	0.71	0.70	0.75	0.66	0.63	0.71	0.67	0.64	0.72	0.60	0.57	0.65	0.61	0.57	0.64
Y/R at F40	0.65	0.64	0.69	0.60	0.58	0.66	0.61	0.59	0.66	0.55	0.52	0.59	0.55	0.52	0.58
Y/R at 65% FSPR30	0.62	-	-	0.62	-	-	0.62	-	-	0.52	-	-	0.52	-	-
Y/R at 75% FSPR30	0.66	-	-	0.64	-	-	0.65	-	-	0.55	-	-	0.55	-	-
Y/R at 85% FSPR30	0.68	-	-	0.66	-	-	0.67	-	-	0.58	-	-	0.58	-	-
M	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
F2006	0.22	0.17	0.29	0.22	0.19	0.50	0.20	0.17	0.37	0.23	0.20	0.47	0.63	0.60	0.91
F Current	0.16	0.14	0.21	0.22	0.18	0.29	0.19	0.16	0.25	0.23	0.18	0.31	0.36	0.31	0.46
SSB 2006	4543.0	3657.0	5432.0	4398.0	3523.0	5260.0	5388.0	4299.0	6506.0	5182.0	4160.0	6264.0	3027.0	2536.0	3354.0
SSB2006/SSBSPR30	1.54	1.24	1.83	1.48	1.19	1.78	1.57	1.26	1.89	1.65	1.33	2.00	1.11	0.93	1.22
F2006/FSPR30	0.98	0.85	1.20	0.82	0.86	1.58	0.81	0.83	1.31	0.73	0.76	1.26	2.20	2.38	2.70
MFMT	0.22	0.21	0.24	0.27	0.22	0.31	0.24	0.21	0.28	0.32	0.26	0.38	0.29	0.25	0.34
MSST	2444.6	2440.0	2448.3	2447.0	2439.7	2447.2	2828.7	2828.2	2837.5	2591.7	2584.0	2591.1	2260.1	2256.0	2263.0

3.2.2.10. Projections

Projection results are summarized for the Atlantic and Gulf base cases, 2006-2016, in **Figures 3.22 - 3.25** and **Tables 3.44-3.50**. For each base case, two types of projections were made. The used the VPA recruitment estimates for all years. The second set replaced the 2005 and 2006 recruitment estimates with the predictions from the S-R relationship.

Figure 3.22. Projections results for the Atlantic base case without replacing the 2005 and 2006 recruitment estimates.

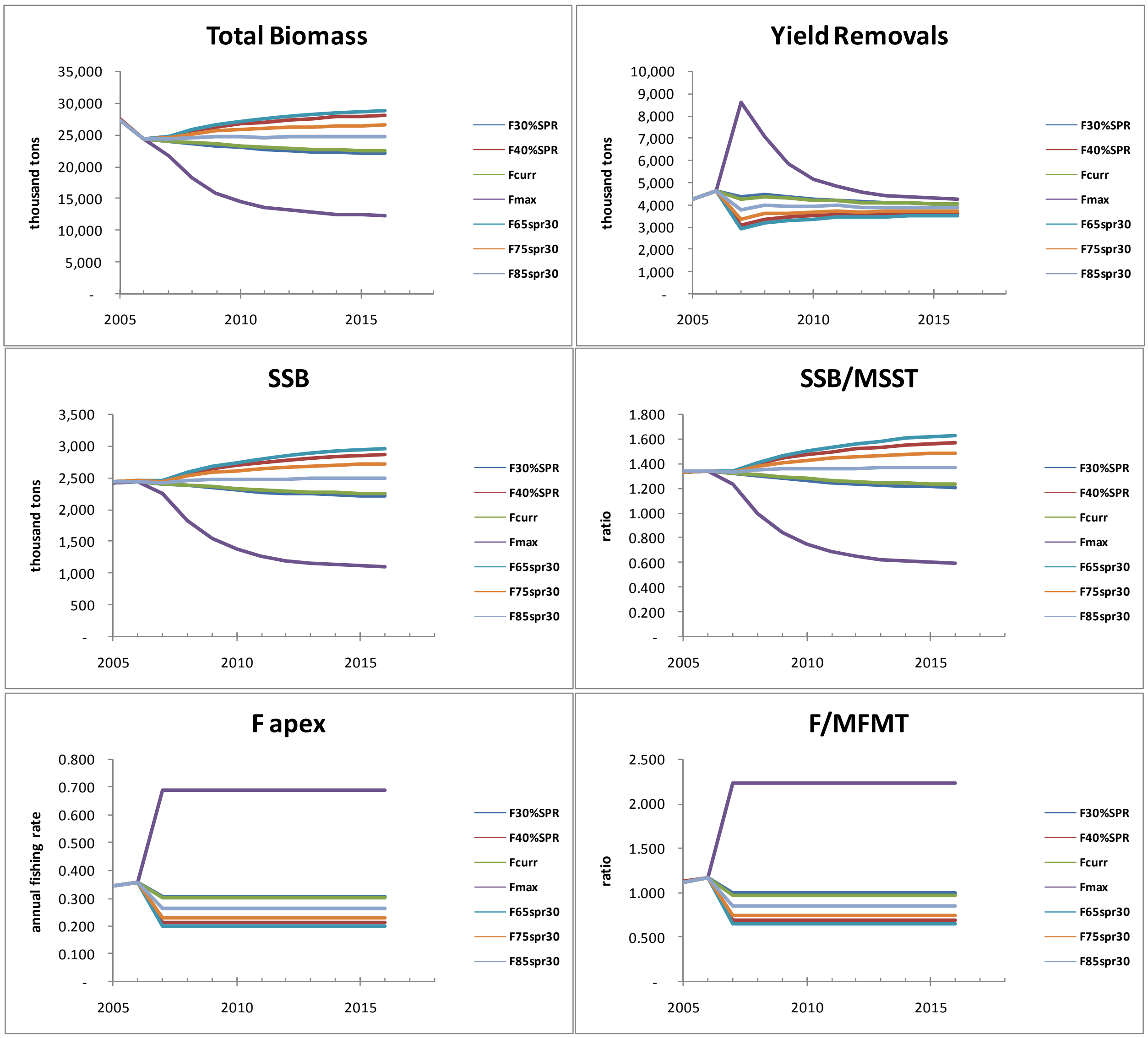


Table 3.44. Projections results for the Atlantic base case without replacing the 2005 and 2006 recruitment estimates.

	Year											
Scenario	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total Biomass												
F30%SPR	27,390	24,350	24,040	23,740	23,380	23,040	22,760	22,580	22,430	22,340	22,240	22,170
F40%SPR	27,390	24,350	24,700	25,580	26,210	26,640	26,960	27,270	27,500	27,710	27,860	27,980
Fcurr	27,390	24,350	24,100	23,890	23,610	23,320	23,080	22,930	22,800	22,720	22,640	22,580
Fmax	27,390	24,350	21,750	18,150	15,860	14,470	13,600	13,060	12,710	12,480	12,320	12,210
F65spr30	27,390	24,350	24,770	25,800	26,550	27,090	27,510	27,900	28,190	28,450	28,640	28,790
F75spr30	27,390	24,350	24,560	25,190	25,590	25,830	26,000	26,180	26,310	26,440	26,510	26,580
F85spr30	27,390	24,350	24,350	24,590	24,670	24,660	24,620	24,640	24,640	24,650	24,640	24,640
SSB												
F30%SPR	2,433	2,443	2,401	2,378	2,342	2,307	2,275	2,253	2,237	2,229	2,216	2,207
F40%SPR	2,433	2,443	2,440	2,554	2,636	2,695	2,738	2,775	2,808	2,839	2,855	2,870
Fcurr	2,433	2,443	2,404	2,393	2,365	2,337	2,311	2,292	2,279	2,273	2,262	2,254
Fmax	2,433	2,443	2,256	1,823	1,540	1,368	1,261	1,194	1,151	1,124	1,104	1,091
F65spr30	2,433	2,443	2,444	2,575	2,672	2,744	2,798	2,845	2,885	2,923	2,944	2,963
F75spr30	2,433	2,443	2,432	2,517	2,572	2,608	2,633	2,655	2,674	2,695	2,702	2,710
F85spr30	2,433	2,443	2,419	2,460	2,476	2,482	2,481	2,482	2,485	2,492	2,489	2,489
Yield Removals												
F30%SPR	4,242	4,628	4,371	4,469	4,352	4,262	4,237	4,142	4,105	4,097	4,073	4,060
F40%SPR	4,242	4,628	3,097	3,364	3,441	3,495	3,571	3,550	3,563	3,593	3,596	3,603
Fcurr	4,242	4,628	4,265	4,383	4,286	4,210	4,194	4,105	4,072	4,068	4,046	4,034
Fmax	4,242	4,628	8,585	7,023	5,816	5,149	4,802	4,557	4,424	4,347	4,290	4,252
F65spr30	4,242	4,628	2,948	3,225	3,318	3,385	3,470	3,457	3,475	3,510	3,515	3,525
F75spr30	4,242	4,628	3,366	3,611	3,655	3,684	3,741	3,705	3,708	3,730	3,727	3,729
F85spr30	4,242	4,628	3,774	3,972	3,958	3,942	3,968	3,907	3,894	3,904	3,892	3,888
F apex												
F30%SPR	0.344	0.359	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308
F40%SPR	0.344	0.359	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
Fcurr	0.344	0.359	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Fmax	0.344	0.359	0.686	0.686	0.686	0.686	0.686	0.686	0.686	0.686	0.686	0.686
F65spr30	0.344	0.359	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
F75spr30	0.344	0.359	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
F85spr30	0.344	0.359	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262
SSB/MSST												
F30%SPR	1.332	1.338	1.315	1.302	1.282	1.263	1.246	1.234	1.225	1.220	1.213	1.208
F40%SPR	1.332	1.338	1.336	1.398	1.443	1.476	1.499	1.519	1.537	1.554	1.563	1.571
Fcurr	1.332	1.338	1.316	1.310	1.295	1.280	1.265	1.255	1.248	1.244	1.238	1.234
Fmax	1.332	1.338	1.235	0.998	0.843	0.749	0.690	0.654	0.630	0.615	0.604	0.597
F65spr30	1.332	1.338	1.338	1.410	1.463	1.502	1.532	1.558	1.580	1.600	1.612	1.622
F75spr30	1.332	1.338	1.332	1.378	1.408	1.428	1.442	1.454	1.464	1.476	1.479	1.484
F85spr30	1.332	1.338	1.324	1.347	1.356	1.359	1.358	1.359	1.361	1.364	1.363	1.363
F/MFMT												
F30%SPR	1.117	1.163	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
F40%SPR	1.117	1.163	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685
Fcurr	1.117	1.163	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973
Fmax	1.117	1.163	2.226	2.226	2.226	2.226	2.226	2.226	2.226	2.226	2.226	2.226
F65spr30	1.117	1.163	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
F75spr30	1.117	1.163	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
F85spr30	1.117	1.163	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850

Figure 3.23. Projections results for the Atlantic base case with replacement of the 2005 and 2006 recruitment estimates.

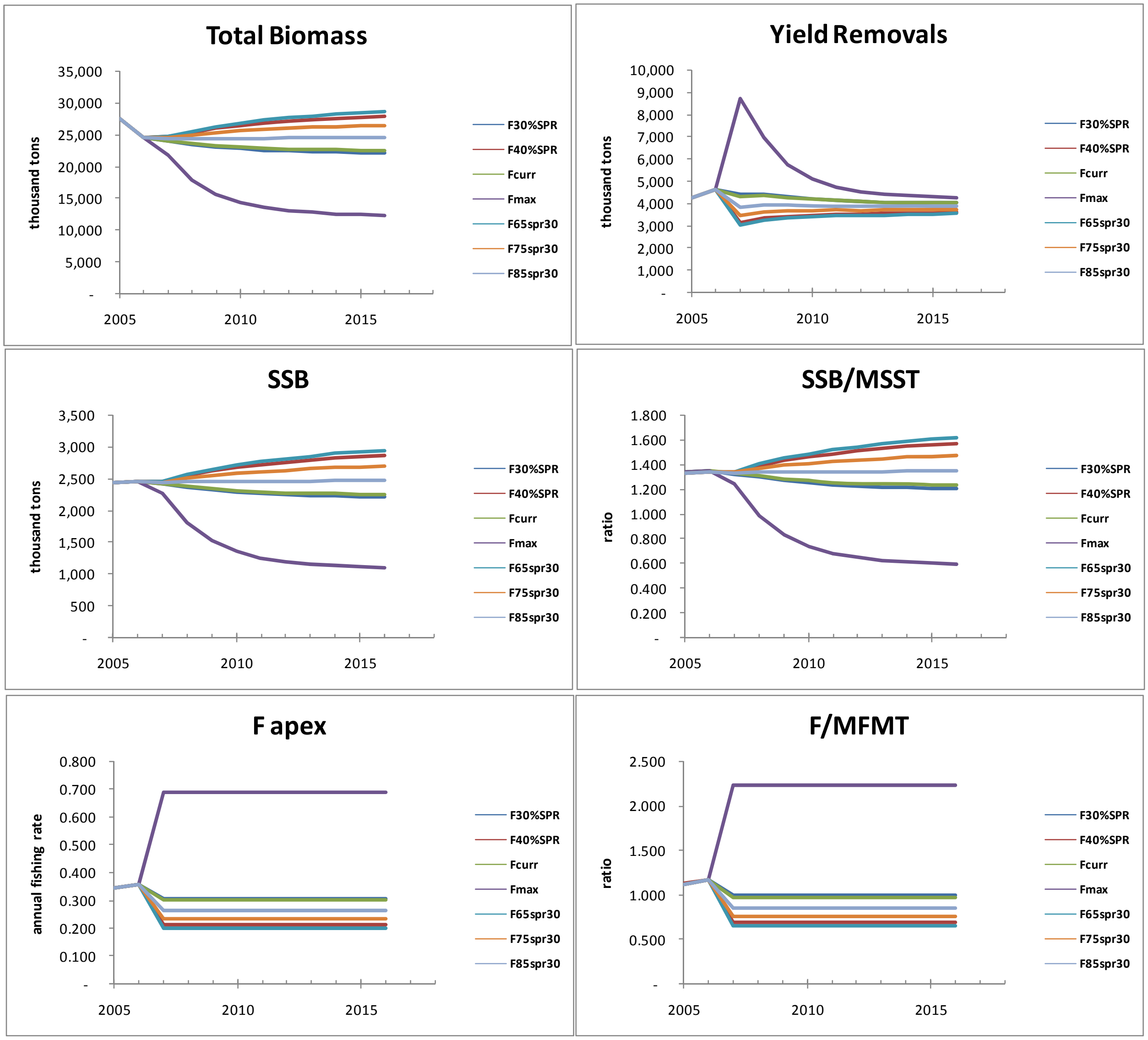


Table 3.45. Projections results for the Atlantic base case with replacement of the 2005 and 2006 recruitment estimates.

	Year											
Scenario	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total Biomass												
F30%SPR	27,460	24,520	24,000	23,500	23,130	22,820	22,580	22,450	22,340	22,270	22,190	22,140
F40%SPR	27,460	24,520	24,660	25,350	25,960	26,400	26,760	27,100	27,370	27,610	27,780	27,920
Fcurr	27,460	24,520	24,050	23,650	23,350	23,090	22,900	22,790	22,700	22,650	22,590	22,540
Fmax	27,460	24,520	21,670	17,860	15,620	14,300	13,500	13,000	12,670	12,460	12,300	12,200
F65spr30	27,460	24,520	24,730	25,540	26,260	26,790	27,230	27,630	27,950	28,240	28,440	28,610
F75spr30	27,460	24,520	24,510	24,920	25,280	25,530	25,730	25,930	26,090	26,240	26,330	26,410
F85spr30	27,460	24,520	24,300	24,320	24,360	24,350	24,350	24,400	24,420	24,470	24,470	24,490
SSB												
F30%SPR	2,433	2,457	2,412	2,366	2,321	2,283	2,254	2,237	2,226	2,220	2,210	2,204
F40%SPR	2,433	2,457	2,451	2,543	2,615	2,671	2,714	2,755	2,791	2,826	2,845	2,863
Fcurr	2,433	2,457	2,415	2,380	2,344	2,313	2,289	2,275	2,266	2,263	2,255	2,250
Fmax	2,433	2,457	2,265	1,804	1,517	1,349	1,248	1,186	1,147	1,121	1,102	1,090
F65spr30	2,433	2,457	2,455	2,561	2,646	2,713	2,765	2,814	2,857	2,898	2,921	2,943
F75spr30	2,433	2,457	2,442	2,502	2,545	2,577	2,600	2,625	2,647	2,671	2,681	2,691
F85spr30	2,433	2,457	2,429	2,445	2,449	2,450	2,449	2,454	2,460	2,469	2,470	2,471
Yield Removals												
F30%SPR	4,242	4,628	4,430	4,437	4,313	4,221	4,176	4,100	4,079	4,072	4,062	4,054
F40%SPR	4,242	4,628	3,138	3,344	3,415	3,467	3,521	3,512	3,538	3,566	3,582	3,595
Fcurr	4,242	4,628	4,324	4,353	4,249	4,171	4,134	4,064	4,047	4,043	4,034	4,028
Fmax	4,242	4,628	8,715	6,938	5,730	5,077	4,737	4,525	4,409	4,336	4,285	4,250
F65spr30	4,242	4,628	3,008	3,225	3,310	3,373	3,436	3,433	3,463	3,495	3,513	3,529
F75spr30	4,242	4,628	3,434	3,609	3,644	3,668	3,702	3,678	3,694	3,714	3,724	3,732
F85spr30	4,242	4,628	3,851	3,967	3,942	3,921	3,924	3,878	3,879	3,888	3,889	3,890
F apex												
F30%SPR	0.344	0.359	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308
F40%SPR	0.344	0.359	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
Fcurr	0.344	0.359	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Fmax	0.344	0.359	0.687	0.687	0.687	0.687	0.687	0.687	0.687	0.687	0.687	0.687
F65spr30	0.344	0.359	0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202	0.202
F75spr30	0.344	0.359	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
F85spr30	0.344	0.359	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264
SSB/MSST												
F30%SPR	1.331	1.344	1.320	1.295	1.270	1.249	1.233	1.224	1.218	1.215	1.209	1.206
F40%SPR	1.331	1.344	1.341	1.391	1.431	1.462	1.485	1.507	1.527	1.546	1.557	1.567
Fcurr	1.331	1.344	1.321	1.302	1.283	1.266	1.252	1.245	1.240	1.238	1.234	1.231
Fmax	1.331	1.344	1.239	0.987	0.830	0.738	0.683	0.649	0.628	0.613	0.603	0.596
F65spr30	1.331	1.344	1.343	1.401	1.448	1.485	1.513	1.540	1.563	1.586	1.598	1.610
F75spr30	1.331	1.344	1.336	1.369	1.393	1.410	1.423	1.436	1.448	1.462	1.467	1.472
F85spr30	1.331	1.344	1.329	1.338	1.340	1.341	1.340	1.343	1.346	1.351	1.352	1.352
F/MFMT												
F30%SPR	1.117	1.163	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
F40%SPR	1.117	1.163	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685
Fcurr	1.117	1.163	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973	0.973
Fmax	1.117	1.163	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230
F65spr30	1.117	1.163	0.655	0.655	0.655	0.655	0.655	0.655	0.655	0.655	0.655	0.655
F75spr30	1.117	1.163	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755	0.755
F85spr30	1.117	1.163	0.856	0.856	0.856	0.856	0.856	0.856	0.856	0.856	0.856	0.856
SSB/SSBtarget												
F30%SPR	0.831	0.839	0.823	0.808	0.792	0.779	0.769	0.764	0.760	0.758	0.754	0.752
F40%SPR	0.831	0.839	0.837	0.868	0.893	0.912	0.926	0.940	0.953	0.965	0.971	0.977
Fcurr	0.831	0.839	0.824	0.812	0.800	0.790	0.781	0.777	0.774	0.773	0.770	0.768
Fmax	0.831	0.839	0.773	0.616	0.518	0.461	0.426	0.405	0.392	0.383	0.376	0.372
F65spr30	0.831	0.839	0.838	0.874	0.903	0.926	0.944	0.961	0.975	0.989	0.997	1.005
F75spr30	0.831	0.839	0.834	0.854	0.869	0.880	0.888	0.896	0.904	0.912	0.915	0.919
F85spr30	0.831	0.839	0.829	0.835	0.836	0.836	0.836	0.838	0.840	0.843	0.843	0.844
F/Ftarget												
F30%SPR	1.630	1.698	1.460	1.460	1.460	1.460	1.460	1.460	1.460	1.460	1.460	1.460
F40%SPR	1.630	1.698	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Fcurr	1.630	1.698	1.420	1.420	1.420	1.420	1.420	1.420	1.420	1.420	1.420	1.420
Fmax	1.630	1.698	3.254	3.254	3.254	3.254	3.254	3.254	3.254	3.254	3.254	3.254
F65spr30	1.630	1.698	0.956	0.956	0.956	0.956	0.956	0.956	0.956	0.956	0.956	0.956
F75spr30	1.630	1.698	1.102	1.102	1.102	1.102	1.102	1.102	1.102	1.102	1.102	1.102
F85spr30	1.630	1.698	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250

Figure 3.24. Projections results for the Gulf base case without replacing the 2005 and 2006 recruitment estimates.

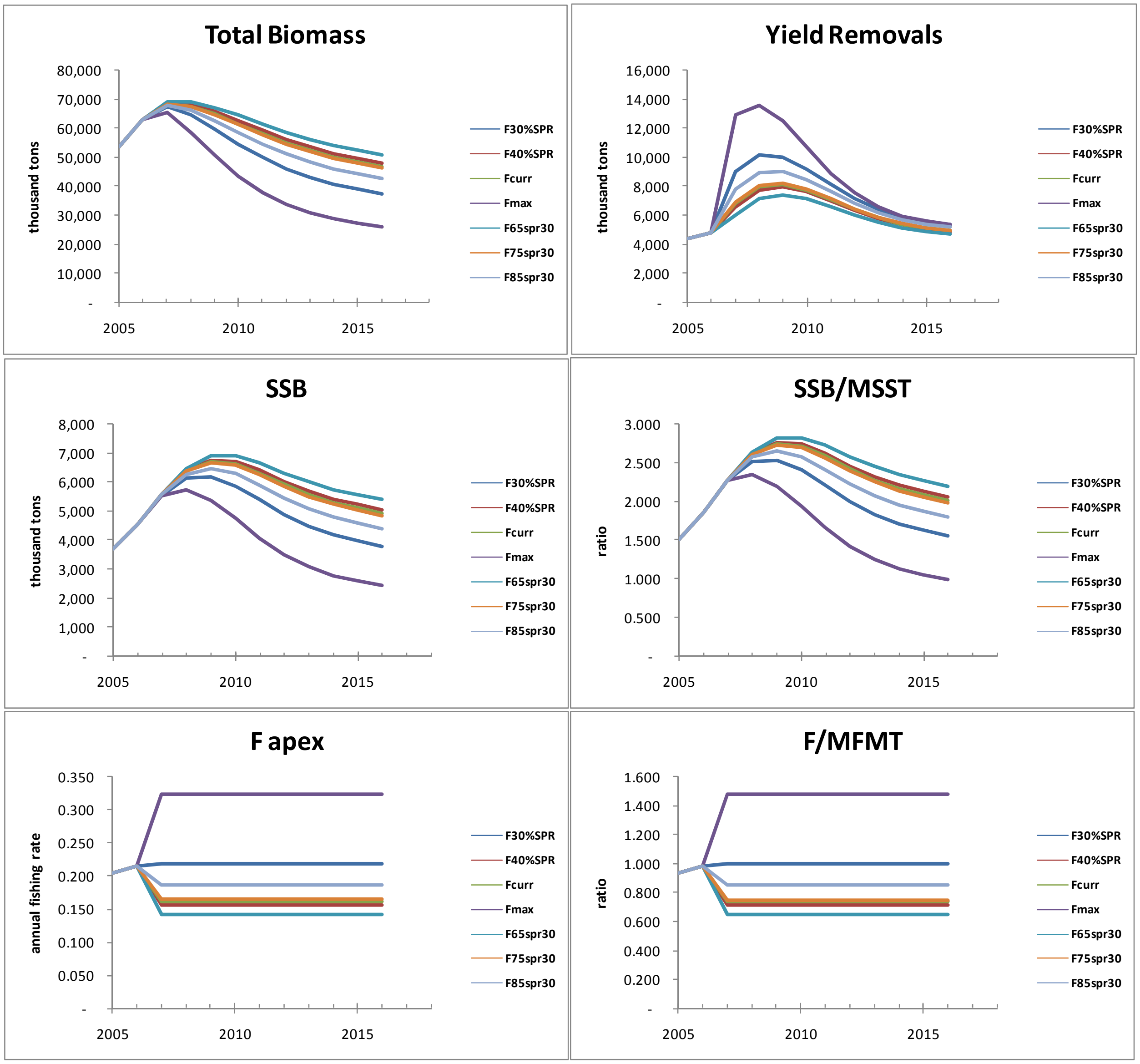


Table 3.46. Projections results for the Gulf base case without replacing the 2005 and 2006 recruitment estimates.

						Year						
Scenario	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total Biomass												
F30%SPR	53,620	63,020	67,290	64,310	59,490	54,340	49,800	45,990	43,050	40,750	38,950	37,450
F40%SPR	53,620	63,020	68,520	68,130	65,710	62,430	59,160	56,090	53,540	51,400	49,600	48,000
Fcurr	53,620	63,020	68,410	67,770	65,110	61,640	58,220	55,060	52,460	50,290	48,480	46,880
Fmax	53,620	63,020	65,320	58,510	50,570	43,390	37,810	33,660	30,730	28,640	27,130	25,960
F65spr30	53,620	63,020	68,800	69,000	67,160	64,370	61,450	58,620	56,220	54,160	52,400	50,810
F75spr30	53,620	63,020	68,360	67,620	64,850	61,300	57,830	54,620	52,000	49,820	48,000	46,410
F85spr30	53,620	63,020	67,930	66,270	62,640	58,400	54,450	50,950	48,160	45,900	44,080	42,510
SSB												
F30%SPR	3,690	4,543	5,557	6,147	6,197	5,884	5,397	4,893	4,485	4,184	3,972	3,788
F40%SPR	3,690	4,543	5,557	6,408	6,754	6,705	6,412	6,025	5,682	5,417	5,229	5,046
Fcurr	3,690	4,543	5,557	6,383	6,700	6,625	6,311	5,910	5,558	5,288	5,096	4,912
Fmax	3,690	4,543	5,557	5,741	5,381	4,751	4,074	3,496	3,076	2,788	2,594	2,442
F65spr30	3,690	4,543	5,557	6,466	6,882	6,899	6,659	6,307	5,987	5,737	5,560	5,383
F75spr30	3,690	4,543	5,557	6,373	6,678	6,591	6,268	5,861	5,506	5,233	5,040	4,856
F85spr30	3,690	4,543	5,557	6,282	6,480	6,297	5,903	5,451	5,069	4,781	4,576	4,390
Yield Removals												
F30%SPR	4,361	4,773	9,037	10,160	10,020	9,201	8,091	7,154	6,390	5,844	5,513	5,304
F40%SPR	4,361	4,773	6,585	7,715	7,936	7,603	6,945	6,312	5,742	5,309	5,043	4,878
Fcurr	4,361	4,773	6,815	7,953	8,149	7,776	7,079	6,417	5,827	5,381	5,108	4,937
Fmax	4,361	4,773	12,880	13,540	12,460	10,690	8,857	7,524	6,564	5,935	5,565	5,333
F65spr30	4,361	4,773	6,039	7,138	7,412	7,166	6,602	6,039	5,517	5,115	4,869	4,716
F75spr30	4,361	4,773	6,913	8,055	8,240	7,849	7,134	6,460	5,861	5,410	5,134	4,962
F85spr30	4,361	4,773	7,773	8,929	8,999	8,447	7,576	6,793	6,123	5,630	5,328	5,139
F apex												
F30%SPR	0.205	0.216	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219
F40%SPR	0.205	0.216	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
Fcurr	0.205	0.216	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162
Fmax	0.205	0.216	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
F65spr30	0.205	0.216	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142
F75spr30	0.205	0.216	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
F85spr30	0.205	0.216	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
SSB/MSST												
F30%SPR	1.509	1.858	2.273	2.515	2.535	2.407	2.208	2.002	1.835	1.712	1.625	1.550
F40%SPR	1.509	1.858	2.273	2.621	2.763	2.743	2.623	2.465	2.324	2.216	2.139	2.064
Fcurr	1.509	1.858	2.273	2.611	2.741	2.710	2.582	2.418	2.274	2.163	2.085	2.009
Fmax	1.509	1.858	2.273	2.348	2.201	1.943	1.667	1.430	1.258	1.140	1.061	0.999
F65spr30	1.509	1.858	2.273	2.645	2.815	2.822	2.724	2.580	2.449	2.347	2.274	2.202
F75spr30	1.509	1.858	2.273	2.607	2.732	2.696	2.564	2.398	2.252	2.141	2.062	1.986
F85spr30	1.509	1.858	2.273	2.570	2.651	2.576	2.415	2.230	2.074	1.956	1.872	1.796
F/MFMT												
F30%SPR	0.934	0.984	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
F40%SPR	0.934	0.984	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712
Fcurr	0.934	0.984	0.739	0.739	0.739	0.739	0.739	0.739	0.739	0.739	0.739	0.739
Fmax	0.934	0.984	1.479	1.479	1.479	1.479	1.479	1.479	1.479	1.479	1.479	1.479
F65spr30	0.934	0.984	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
F75spr30	0.934	0.984	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750
F85spr30	0.934	0.984	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850	0.850

Figure 3.25. Projections results for the Gulf base case with replacement of the 2005 and 2006 recruitment estimates.

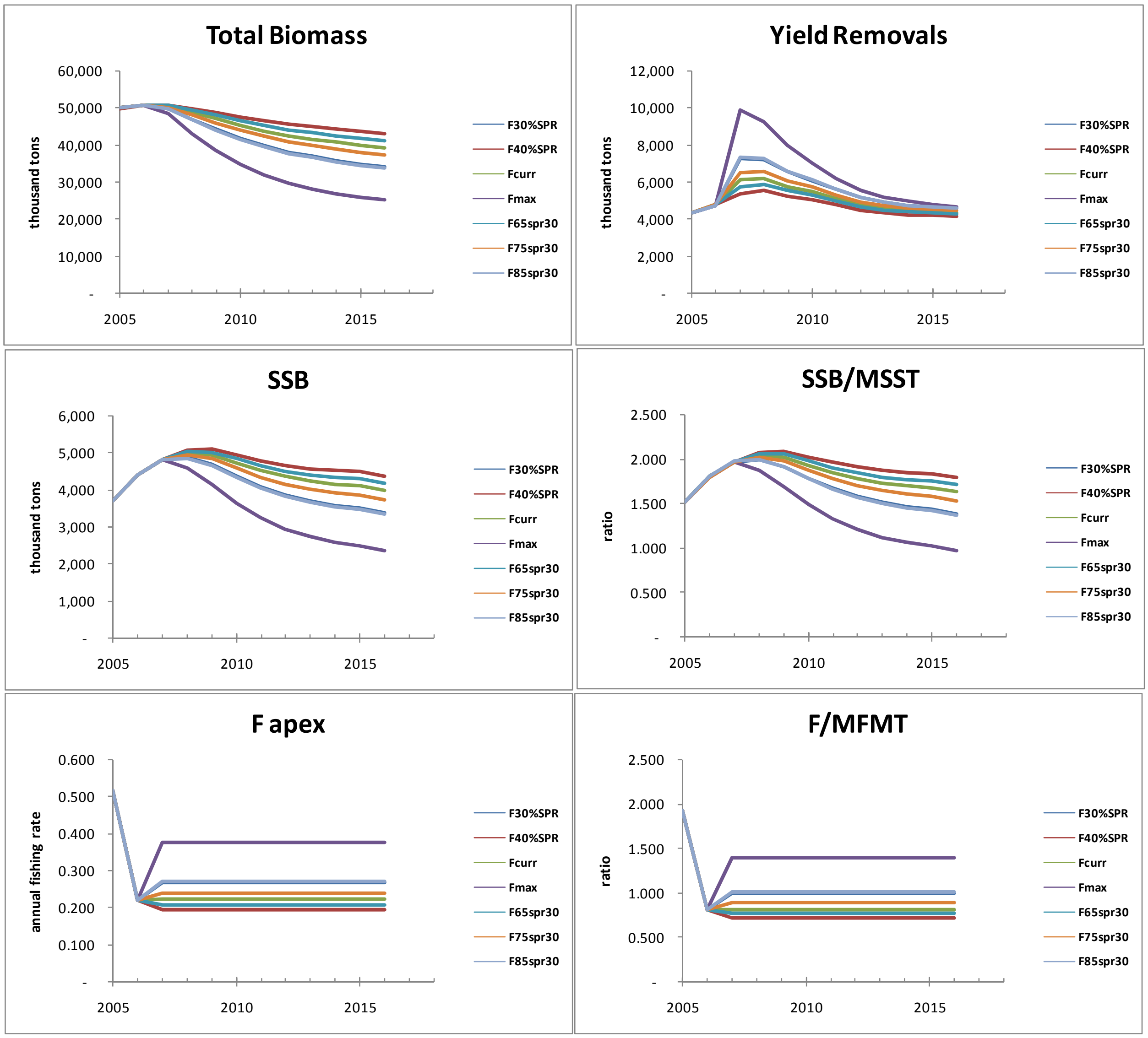
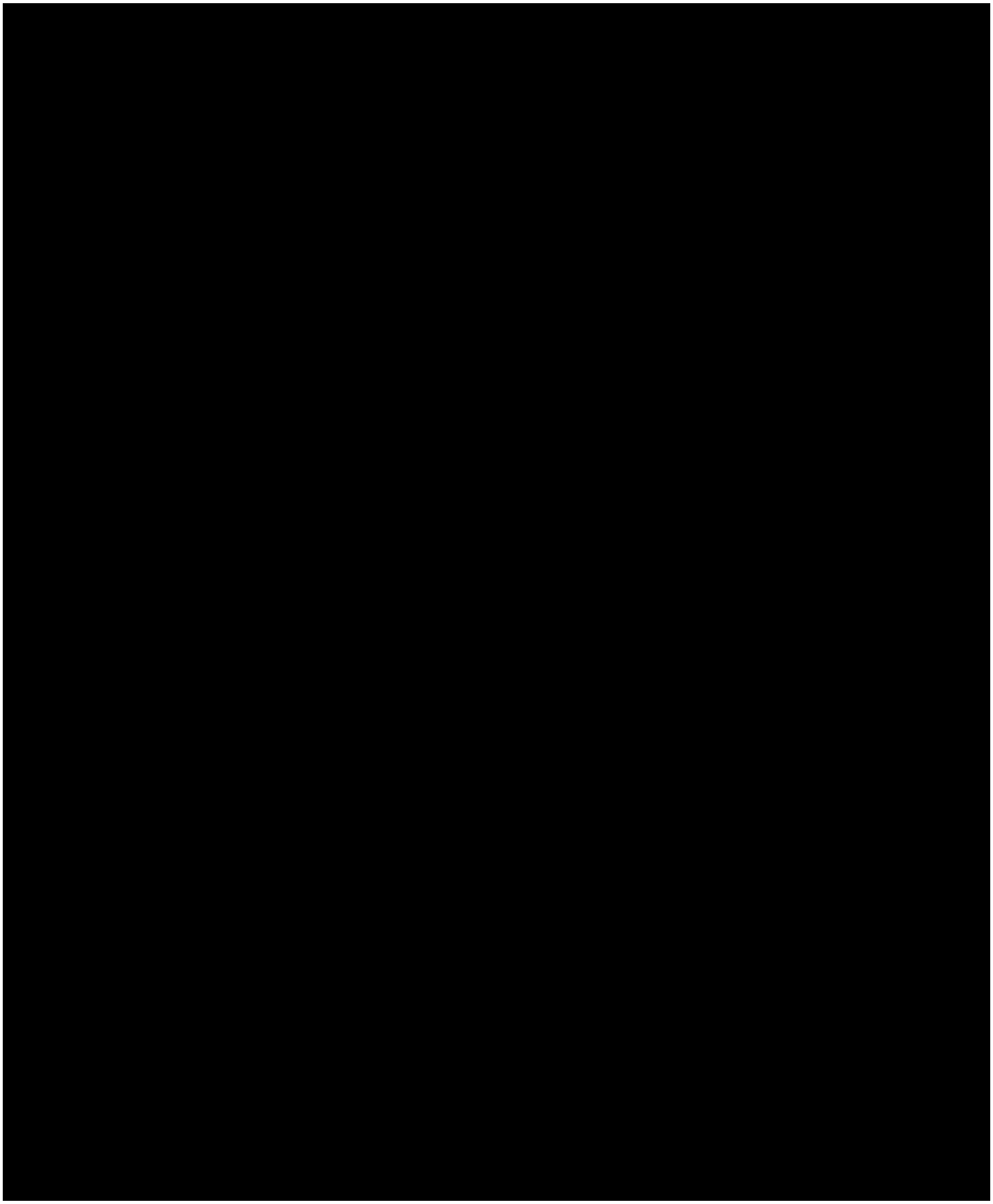


Table 3.47. Projections results for the Gulf base case with replacement of the 2005 and 2006 recruitment estimates.



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Appendix 1 - Analysts' Notes on the Calculation of Current Selectivity and Current F

According to the decisions made by the SEDAR 16 AW, "current selectivity" is determined from the fishing mortalities by age for the last five years in the analyses. For each age, the geometric mean F for the period 2002-2006 is calculated, and the selectivity vector is computed by re-scaling the resulting vector to a maximum of 1.0. In addition, the SEDAR 16 AW decided to use the terminal (2006) F as the "current F" (for 2006) to determine if overfishing is occurring, i.e. if F_{2006}>MFMT. The analysts have understood that F_{2006} is simply the apical F for 2006, i.e. the highest value in the age-specific F vector for that year.

The above approach can result in situations where there are inconsistencies between the current selectivity (the mean for 2002-2006) and the terminal (2006) selectivity. See for example Figure A1, where the higher selectivities for the "terminal" vector are shifted to older ages relative to the "current" vector. It is evident that if the various benchmarks (F_{MSY}~$F_{30\%}$, etc.) are based on the current vector, then comparisons made on the basis of the terminal vector will be inconsistent.

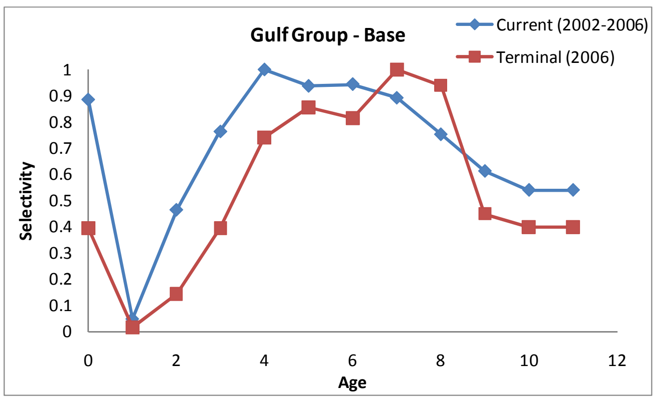

Figure A1. Comparison of "Current" selectivity and "Terminal" selectivity from the Gulf Base VPA results.

Using the Gulf results as an example, $F_{30\%}$ is estimated to be equal to 0.22 or 0.33, using the mean 2002-2006 or the 2006 selectivity vectors respectively. The apical F in 2006 is equal to 0.22, and the geometric mean F for 2002-2006 is equal to 0.16. If one compares the 2006 apical F to the $F_{30\%}$ from the five-year geometric mean, one would conclude that $F_{current}$ == $F_{30\%}$, but this is misleading because the implications in terms of equilibrium SSB of fishing at F=0.22 are quite different for the two selectivity vectors in question. More consistent comparisons would be: (a) compare F2002-2006 against $F_{30\%}$ based on the 2002-2006 selectivity (F=0.16 < $F_{30\%}$=0.22), or (b) compare F2006 against F30% based on the 2006 selectivity (F=0.22 < $F_{30\%}$=0.33).

There are several approaches that could be considered to deal with this inconsistency, such as:

1) Use Current F for Status Determination. In this case, both $F_{30\%}$ and current F would be based on the average vectors for 2002-2006, so the estimates would be entirely consistent. From a VPA modeling perspective, this choice is appealing because the last few years in a VPA are highly uncertain, and this approach would smooth out variations to an average for recent years. From the perspective of the National Standard Guidelines this may not be an ideal choice since "overfishing" would not be measured annually, but by a multi-year average. (Note, however, that this problem could be reduced somewhat if a shorter time series, e.g. 2004-2006, were used to compute current selectivity and current F).

2) Define current selectivity based only on the terminal year. In this case there would be consistency again because the current and terminal year selectivity vectors would be one and the same. From a VPA modeling perspective, this choice is subject to considerable uncertainty because the terminal F vector is estimated with very low precision.

3) Define terminal F as an average over several ages. The approach here would be to compare the current and terminal selectivity vectors and look for a range of ages that have similar selectivities close to 1.0. For example, such a range in Figure A1 could be ages 4 to 8. This approach is admittedly subjective and it would not eliminate the inconsistencies entirely. But it would make the impact of the inconsistencies less pronounced.

The analysts recommend that SEDAR 16 take this problem into consideration to resolve inconsistencies in making status determinations.