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

Continuity Case and Updated Runs

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1. INTRODUCTION

The Virtual Population Analysis (VPA) results described in this document provide an update of the previous Gulf king mackerel (SEDAR5) and Atlantic king mackerel (MSAP 2003) stock assessments. 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.

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 important 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 (MSAP 2003) indicated that harvest rates were below the MFMT and overfishing was not occurring as of 2001. This 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 VPA Theory

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[1]. 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 1.1**).

Table 1.1. 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
$C_{kay} = \tilde{N}_{kay} \frac{F_{kay}(1 - e^{-Z_{kay}})}{Z_{kay}}$	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*

[1] 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.)

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*

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 1.1**) 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 1.2**.

Table 1.2. Model for indices of abundance (index series: *i*, zone: *k*, age: *a*, year: *y*).

$\mathcal{L}(\bar{I}) = -\sum_i \sum_k \sum_y 0.5\left(\frac{\ln\left(I_{iky}/\hat{I}_{iky}\right)}{\sigma_{iky}}\right)^2 - \ln \sigma_{iky}$	log-likelihood term for lognormally distributed indices of abundance
$\hat{I}_{iky} = q_{iky}\sum_a s_{ika} w_{ikay} \tilde{N}_{kay}$	predicted value of index
$s_{ika} = \frac{\sum_y C_{ikay} F_{kay}/C_{kay}}{\text{MAX}_a\left\{\sum_y C_{ikay} F_{kay}/C_{kay}\right\}}$	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. The values of *S* were determined from the partial catches corresponding to each index (e.g., Powers and Restrepo, 1992; Butterworth and Geromont, 1999). "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.

1.3 Objectives (TORs)

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 three main types of VPA analyses for each migratory group:

- A "Continuity run", where all modeling and data treatment choices are kept as close as possible to those made for SEDAR 5;

- Two runs using the data treatment and modeling choices agreed to by the Assessment Workshop, in which the catches of king mackerel within the mixing zone were either

    - a) attributed to belong 100% to the Gulf Migratory Group, or

    -b) attributed to belong 50%-50% to the Gulf and Atlantic migratory groups.

2. MODEL SPECIFICATIONS AND INPUTS

2.1 Continuity Run (SEDAR5)

Prior assessments of the Atlantic and Gulf migratory groups used a related age structure VPA model, specifically the software package F-ADAPT (Restrepo, 1996). This program required a catch-at-age matrix, vectors of natural mortality by age, weight-at-age and relative indices of abundance. In addition, each index required an annual specification of selectivity-at-age or partial catches-at-age.

During this assessment (SEDAR16), continuity runs used a different VPA software program, VPA-2BOX ver. 3.0.5 May 2004 (Porch, 2003). This version of VPA-2BOX is included in the NOAA Fisheries Toolbox package (NFT). The Atlantic and Gulf "continuity runs" were run using F-ADAPT and VPA-2BOX using the same inputs and model specifications to ensure that both programs provided identical solutions and results. The setting and input data are summarized in **Tables 2.1** - **2.9**.

Table 2.1. Model settings and inputs used to construct the "Continuity Runs" and compare F-ADAPT and VPA2-BOX results.

Settings/Input Series	F-ADAPT & VPA-2BOX Continuity Runs
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, and north of Monroe County, FL 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/MSAP 2003, catch and Indices estimated using "fishing year" definitions.
Directed Landings/Discards	Like SEDAR5/MSAP 2003, 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/MSAP 2003 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/MSAP2003.
Indices of Abundance	Used same indices selected for SEDAR5/MSAP 2003 assessment. In general, used identical methods to update indices through 2006.
Natural Mortality	Like SEDAR5/MSAP 2003, constant natural mortality rate M: 0.20 for GOM king, and 0.15 for ATL king
Terminal Year F-at-age	Like SEDAR5/MSAP 2003, $F_{0,2006}$ 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/MSAP 2003, 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 2.2**.

Table 2.2. 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 2.3 and 2.4**.

Table 2.3. 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 2.4. 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 2.5**) to tune the VPA estimates, while the Gulf run used 9 (**Table 2.6**). 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. 2.5. 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 2.6. 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 2.6. – 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. 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 2.7 and 2.8**. . Like the SEDAR F-ADAPT runs, the partial catches were fit using the Powers and Restrepo (1992) method.

Table 2.7. 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 2.8. 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

Estimated Parameters

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 2.9**.

Table 2.9. Terminal F settings and initial guesses used for VPA continuity runs.

	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

2.2 Updated VPA Runs: Status quo mixing zone assumption (100% Gulf Migratory Unit)

Updated VPA runs using the "status quo mixing zone assumption" were completed that explore the effect of 1) including Age-0 in the Atlantic models, 2) estimating certain terminal-F (fishing mortality) parameters that had previously been fixed , 3) including updated life history information and catch-at-age information developed for, and recommended by the SEDAR 16 data workshop panel, and 4) using a different method to estimate index selectivity by age from partial catches. The general model structure and settings are discussed in **Table 2.10**.

Table 2.10. Model settings and inputs used to construct the "status quo mixing zone assumption" runs.

Settings/Input Series	VPA-2BOX Sensitivity 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 north of Monroe County, FL 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/MSAP 2003, 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 developed at SEFSC (5/2008).
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/MSAP 2003, 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 "status quo mixing zone assumption" runs was unchanged from the values reported in **Table 2.2**. 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 2.11**. Also, revised weight-at-age matrices were developed that vary annually (**Tables 2.12 and 2.13**)

Table 2.11. Biological functions used for "status quo mixing zone assumption" 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	0.539	0.611
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 2.12. Weight -at-age (kg) matrix used the Atlantic "status quo mixing zone assumption" 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 2.13. Weight-at-age (kg) matrix used the Gulf "status quo mixing zone assumption" 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. The catch-at age matrices used to assess the Atlantic and Gulf king mackerel stocks are summarized in **Tables 2.14 and 2.15**.

Table 2.14. Catch-at-age for Atlantic "status quo mixing zone assumption" 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	0	35672	78906	358283	206740	147100	59706	5920	2904	887	7617	13130
1982	31249	76503	30115	209731	330378	133363	61325	30351	9830	8371	28986	13702
1983	58482	244452	116741	164308	216710	100515	90325	15861	3472	611	4152	30929
1984	43352	53696	24394	210030	206758	129792	88558	14853	1444	3454	31614	20183
1985	231128	63108	114282	97705	321304	163845	59548	17235	6325	5398	1000	14911
1986	755	133235	243917	88728	180863	74088	50544	161933	34807	26343	27512	106519
1987	0	200855	190271	123642	84719	69582	66258	23689	79759	26446	9004	88098
1988	0	11224	169088	248235	148843	40910	48946	57322	23271	80482	30763	122057
1989	23369	62077	71593	116613	111495	80035	61207	31929	28914	18827	65037	78861
1990	64146	138599	111099	69265	102039	92464	72800	33575	22263	29688	18202	93347
1991	25742	69730	326546	150259	78180	102995	110150	71356	48286	23594	14953	116022
1992	30063	36983	201047	324169	95063	63538	60135	70044	29665	23312	24589	96613
1993	20991	49416	47794	106572	118703	40286	33049	46898	55855	29241	20537	68821
1994	21055	54129	109990	59827	96869	112573	56406	24562	27947	36827	19294	45031
1995	40141	94989	148738	84249	63985	70374	110488	29409	26603	39014	32784	44061
1996	59534	48417	216263	115257	93689	56491	58454	90635	34034	20637	13895	40411
1997	15744	82785	239772	157118	100398	53058	40020	71326	76150	26215	9875	57850
1998	49479	17286	162512	200505	129975	71513	37593	23994	51305	52853	9227	36373
1999	32003	62587	84771	123714	144399	74197	39228	17302	15582	25391	23899	21029
2000	18381	8987	266881	95955	167185	100460	45311	17305	8561	11847	28938	47148
2001	7198	11257	53816	124177	88291	105683	82835	33940	8711	7768	7664	53653
2002	9090	39102	63478	60890	122299	48926	58141	32207	20109	6831	5898	24763
2003	15383	14657	171375	58196	88858	133313	45731	66270	35241	12605	4982	23409
2004	8185	46019	117914	169432	57727	75769	111079	27534	45316	19051	11341	19133
2005	7202	9314	276084	111133	115814	34598	30625	45234	13526	25381	9006	15206
2006	13120	11551	129395	257047	95582	136444	18669	19118	43700	3487	11490	35008

Table 2.15. Catch-at-age for Gulf "status quo mixing zone assumption" 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	457889	21759	45184	349019	345639	61473	42230	33413	11421	5592	5213	16754
1982	200895	66489	206882	218215	270810	186380	71908	23554	20502	20851	8080	177427
1983	403289	93845	257107	174762	33005	63503	38111	7957	10189	5339	1840	17581
1984	1266812	27484	67445	267019	173723	47578	57322	31791	5513	1058	2660	18762
1985	606329	30050	76321	163999	90595	126159	34022	14938	21233	5825	1907	19138
1986	661436	49663	251871	100864	44481	59879	47359	14453	3034	7109	575	15377
1987	1176482	129728	96838	38207	30059	34594	18640	9163	5218	3707	2478	6934
1988	1339612	57551	116477	110835	79662	38147	85091	34536	7303	15968	15890	36074
1989	2142613	136349	191756	98162	88711	69188	15263	26815	13122	4771	6743	19319
1990	1574647	132936	211964	134229	87831	41082	42104	8031	20931	9417	1719	20608
1991	1466138	193072	275570	155092	85993	47320	32182	15907	5555	22107	6618	13853
1992	1099176	70322	253056	238546	136394	74258	58297	26319	44838	11789	19452	30840
1993	2112479	63242	173910	181521	163644	74327	40877	30509	28585	14895	1923	39162
1994	2306375	131846	198517	147933	190615	133889	78769	46916	27725	22625	44201	37144
1995	1915516	52407	209306	197823	125150	79087	81820	37416	20572	9118	12646	18917
1996	930710	105316	320137	199271	108947	63450	40841	40209	32283	15288	3096	46640
1997	922564	76211	194283	260257	127779	89090	53544	51304	33353	24949	10112	30900
1998	829287	72833	154901	193104	228305	92267	50405	30166	19964	25148	11013	8358
1999	813862	56068	175233	117632	141423	106234	33175	33172	21046	24156	3364	12171
2000	721141	72953	157389	225922	120957	76137	36103	38252	10778	15898	11554	19180
2001	513032	52384	173717	179648	146712	82385	54755	48904	28851	9311	7600	31107
2002	413767	89796	301937	173173	143199	94180	49069	35421	35519	18416	9040	24877
2003	995356	33064	195440	201185	115610	77984	70540	29741	27664	20188	18038	19566
2004	1863281	38407	315619	163760	130810	62351	46887	45315	12431	25754	7236	15584
2005	1231879	27628	209272	218686	146928	91422	62591	49018	35396	12923	11821	31219
2006	595672	24410	220587	249243	193544	123733	68074	49488	31335	20079	9539	33066

The "status quo mixing zone assumption" VPA runs used the updated indices developed for SEDAR 16 SS3 runs. These are summarized in Table 2.16 and 2.17. Index CVs were used to estimate index variance.

Table. 2.16. Indices of abundance and index settings used for the Atlantic "status quo mixing zone assumption" VPA run. Indices were rescaled to the 1981-2006 time period when necessary.

	Trip Ticket - NC PIDs 8+		Com Logbook Mixing		MRFSS-Atl-No-Mix		HB-Atl-no-Mix		SEAMAP South Alt. Trawl	
Type of Index	Fish. Dep. COM		Fish. Dep. REC		Fish. Dep. REC		Fish. Dep. REC		Fish. Independent	
Unit	Weight		Biomass		Number		Number		Numbers	
Likely Applies to Ages	Ages 1-11+		Ages 1-11+		Ages 1-11+		Ages 1-11+		Age 0 Mid-Year	
YEAR	STDCPUE	CV	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			0.651	0.088	0.548	0.645	0.805	0.238	0.446	0.247
1994	0.700	0.068	0.658	0.075	0.355	0.679	0.614	0.249	0.708	0.232
1995	0.744	0.073	0.680	0.074	0.399	0.681	0.617	0.232	1.226	0.198
1996	1.125	0.069	0.947	0.056	0.342	0.677	0.464	0.240	2.261	0.168
1997	1.033	0.060	0.806	0.058	1.126	0.569	1.218	0.206	0.519	0.240
1998	1.056	0.060	1.039	0.044	0.544	0.617	1.243	0.209	1.786	0.200
1999	0.969	0.061	1.003	0.042	0.937	0.590	0.976	0.218	1.213	0.184
2000	0.986	0.059	0.931	0.042	0.811	0.605	1.854	0.209	0.816	0.221
2001	1.044	0.057	0.974	0.041	0.407	0.660	1.288	0.213	0.448	0.234
2002	0.907	0.069	1.053	0.041	0.188	0.779	0.886	0.241	0.506	0.211
2003	0.879	0.073	1.278	0.040	0.271	0.717	0.912	0.227	0.989	0.196
2004	1.292	0.058	1.278	0.044	0.462	0.649	0.896	0.223	0.619	0.357
2005	1.206	0.063	1.270	0.047	0.843	0.577	1.496	0.254	0.726	0.493
2006	1.058	0.066	1.433	0.047	0.598	0.621	1.147	0.219	1.006	0.221

Table. 2.17. Indices of abundance and index settings used for the Gulf "status quo mixing zone assumption" VPA 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 2.18 and 2.19**. The equation used to estimate selectivity was that corresponding to Geromont and Butterworth (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 Geromont and Butterworth approach computes an average selectivity pattern for the entire time period.

Table 2.18. Partial catches at age (numbers) used in the Atlantic "status quo mixing zone assumption" 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	0	173	12227	65110	57445	31395	4744	252	41	3	0	3081
	1982	7480	254	23561	36127	99373	43638	16880	4523	7568	966	475	6835
	1983	6281	22733	22214	15189	15168	23368	20019	150	1206	273	3651	1587
	1984	0	1807	3719	30533	22246	34960	1920	8570	306	1265	1125	403
	1985	0	7094	3245	28130	51267	20872	12777	9239	1886	35	256	4381
	1986	0	2726	13834	9887	28829	12042	9753	29935	7729	5168	4821	19673
	1987	0	15379	32485	26920	20574	19130	18139	5999	20874	6926	2635	25031
	1988	0	148	37532	60620	37557	9213	14273	13513	4413	21024	8301	30900
	1989	0	7757	14002	25773	25099	18285	14356	7498	7360	4448	18165	22611
	1990	0	11450	18753	12452	17009	16766	14799	7495	4950	7296	4466	22751
	1991	0	8326	31777	14556	8465	14863	15794	9696	7151	2487	1349	16169
	1992	39	1810	27727	36131	9577	6423	5774	6298	2668	2412	3909	9120
	1993	454	13027	11567	29861	27387	7186	5802	7067	9542	5366	4254	6799
	1994	0	7753	22230	12127	22386	23264	11539	4080	4521	6716	3287	8765

	1995	0	4542	8095	8617	8666	11233	16787	6460	4791	6642	4522	8286
	1996	0	14729	46198	21695	16316	8660	8576	19115	6709	5618	1431	6532
	1997	0	11877	69409	28711	15912	8423	5028	9403	9014	2839	1153	6817
	1998	371	3397	21462	37654	25553	12296	7552	3238	8783	8180	1624	4400
	1999	0	6791	13959	23544	29231	18132	9333	4418	3000	6773	5017	4625
	2000	0	1043	34232	15559	29850	18143	7451	2790	845	1555	4323	5382
	2001	0	1082	11413	29024	19365	22809	17093	4569	763	1547	311	4124
	2002	40	4781	8925	12280	26721	10025	10996	7328	3936	1023	1859	4606
	2003	0	1951	27620	9558	16314	24381	8368	12066	6447	2393	636	4011
	2004	0	3708	19604	40102	13705	22123	32282	6798	12025	3482	1817	2558
	2005	0	807	29961	14928	18534	6212	7471	10146	3014	7157	2884	4667
	2006	0	2082	16907	52715	24156	36761	6344	6598	14832	840	1577	8699
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 2.19. Partial catches at age (numbers) used in the Gulf "status quo mixing zone assumption" 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

Estimated Parameters

For the "status quo mixing zone assumption" VPA runs, the age-0 to age-10 terminal F parameters were estimated using the following initial conditions and settings (**Table 2.20**). The plus group Terminal F was fixed at the value estimated for Age-10.

Table 2.20. 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	0.006	Estimated	0.054	Estimated
Age 1	0.006	Estimated	0.010	Estimated
Age 2	0.129	Estimated	0.031	Estimated
Age 3	0.234	Estimated	0.050	Estimated
Age 4	0.133	Estimated	0.341	Estimated
Age 5	0.317	Estimated	0.391	Estimated
Age 6	0.120	Estimated	0.140	Estimated
Age 7	0.076	Estimated	0.146	Estimated
Age 8	0.220	Estimated	0.366	Estimated
Age 9	0.093	Estimated	0.099	Estimated
Age 10	0.178	Estimated	0.519	Estimated
Age 11+	-	Fixed equal to Terminal F at Age-10	-	Fixed equal to Terminal F at Age-10

2.3 Updated VPA Runs: Alternative mixing zone assumption (50%-50% Gulf and Atlantic Migratory Units)

All model inputs and specifications were identical to those described in Section 2.2 with one exception, the catch-at-age matrices. These were developed by assigning 50% of the catch in the mixing zone during XXXX to the Gulf of Mexico and 50% to the South Atlantic (**Tables 2.21 and 2.22**).

Table 2.21. Catch-at-age for Atlantic "alternative mixing zone assumption" 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	393904	170238	67469	35987	12792	8784	30446	15783
1983	64856	246550	184379	234067	223375	119537	98117	17377	4571	1227	4499	32314
1984	60338	60613	33887	256122	252638	141253	96851	21031	2201	3595	32413	21815
1985	231157	69218	134553	167574	339599	206094	62100	19329	8846	6265	1005	16881
1986	1104	146195	286293	109075	190402	79391	58391	164003	34869	26607	27512	107084
1987	171	231329	209536	129585	89162	74306	67981	24842	80380	26685	9274	88328
1988	1297	21962	188307	270771	164366	47696	65171	62119	24525	82888	33379	124594
1989	23385	75982	100318	133043	129372	96741	64271	35773	31147	19153	65577	81246
1990	64146	166880	159263	98464	116713	98293	76958	34233	24323	30616	18295	95344
1991	25795	80550	361441	177752	93595	110514	114830	74359	49365	26212	16445	117714
1992	30063	41815	253265	380636	128437	83442	71408	75354	40497	25788	27153	102669
1993	21126	52521	75676	136505	147432	52545	37639	51894	60011	31136	20799	73749
1994	21055	59638	153657	83169	125439	128624	66222	30227	31046	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	23089	17142	27102	24154	22189
2000	18381	17903	290034	146032	190138	112784	52595	21984	10509	13741	29812	48845
2001	7198	15129	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 2.22. Catch-at-age for Gulf "alternative mixing zone assumption" 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	456317	16502	32123	216871	193314	48635	27492	21808	9186	3956	4478	14377
1982	197247	54716	180776	153648	207284	149504	65765	17918	17540	20438	6619	175346
1983	396914	91748	189468	105003	26340	44481	30319	6440	9090	4724	1493	16195
1984	1249826	20567	57951	220927	127844	36116	49028	25614	4755	918	1861	17130
1985	606300	23940	56050	94130	72300	83910	31470	12844	18712	4959	1902	17167
1986	661087	36703	209494	80517	34943	54577	39512	12383	2971	6846	575	14812
1987	1176310	99255	77574	32265	25616	29870	16917	8010	4597	3468	2208	6704
1988	1338315	46813	97259	88300	64139	31361	68867	29739	6050	13561	13274	33536
1989	2142597	122445	163030	81732	70834	52482	12200	22971	10889	4445	6203	16935
1990	1574647	104655	163800	105030	73158	35254	37946	7373	18872	8489	1626	18612
1991	1466085	182252	240676	127600	70578	39801	27502	12904	4475	19490	5126	12161
1992	1099176	65491	200838	182078	103020	54354	47024	21010	34006	9313	16888	24785
1993	2112343	60138	146028	151588	134914	62068	36287	25513	24429	13000	1661	34235
1994	2306375	126336	154850	124591	162044	117838	68954	41251	24627	19865	39629	33969
1995	1915439	47871	174393	162710	103136	64878	67180	31299	17621	7851	10630	16723
1996	930710	87094	242333	156665	86928	53091	35928	35028	27723	12873	2794	41110
1997	922564	54227	153386	203561	103652	71213	45217	45932	29291	21473	8579	28477
1998	829287	58339	118231	153169	168698	71258	39946	24472	17403	20184	9092	7159
1999	813862	45716	127966	94029	116636	88794	28844	27385	19486	22445	3109	11011
2000	721141	64037	134236	175846	98004	63813	28820	33574	8830	14003	10681	17482
2001	513032	48512	145760	146855	117572	69132	47701	42979	25854	7766	6992	28300
2002	413732	70633	204402	130239	112020	73224	39778	30365	30256	15391	7387	21823
2003	995356	27247	151935	158851	96919	67925	58810	25398	25196	17727	15759	17722
2004	1863281	33563	230128	129788	105691	54044	42874	37388	10928	22677	6758	14034
2005	1231843	23552	164254	175586	122746	76873	52471	41831	29796	11442	10628	27227
2006	595672	20093	178244	203485	158511	107711	58659	42905	28343	16720	8995	28893

3. RESULTS

3.1 Continuity Run

The VPA-2Box continuity runs are compared to SEDAR 5 F-ADAPT results in **Figures 3.1 – 3.3**. The differences are not due to the change in software (see Section 1.2). Instead, important differences in the data inputs exist (e.g., updated indices, shrimp bycatch estimates and landings).

Recruitment

For SEDAR 5 and the 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 3.1**). 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.

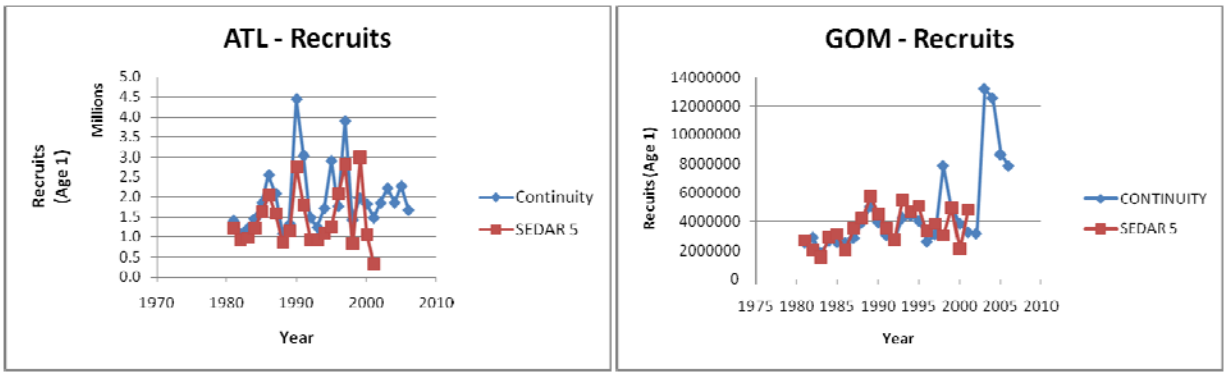

Figure 3.1. Comparison of annual recruitment estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run.

Stock Size

Annual estimates of the size of the adult stock (Age 2+) are summarized in **Figure 3.2.** 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.

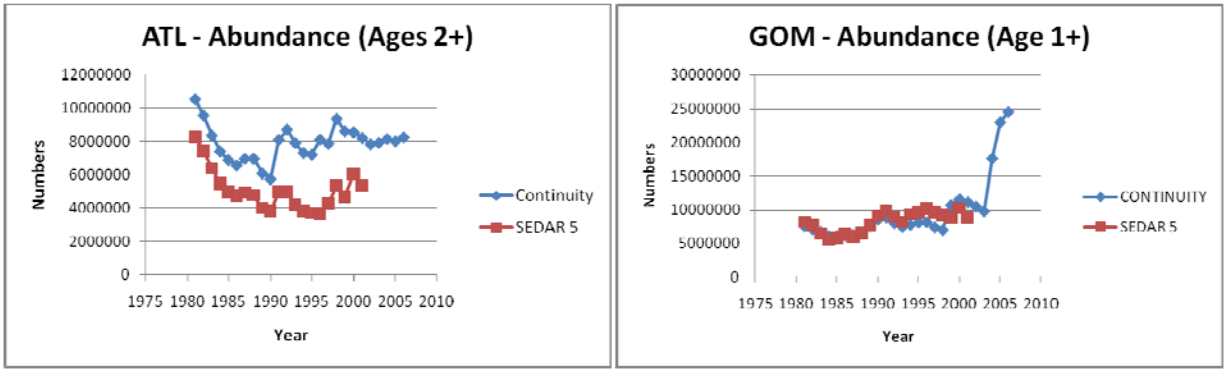

Figure 3.2. Comparison of annual abundance estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run.

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 3.3**). 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 (**Figure 3.3**). The estimates produced by the continuity run are quite variable annually, and are often substantially larger than the estimates from SEDAR 5.

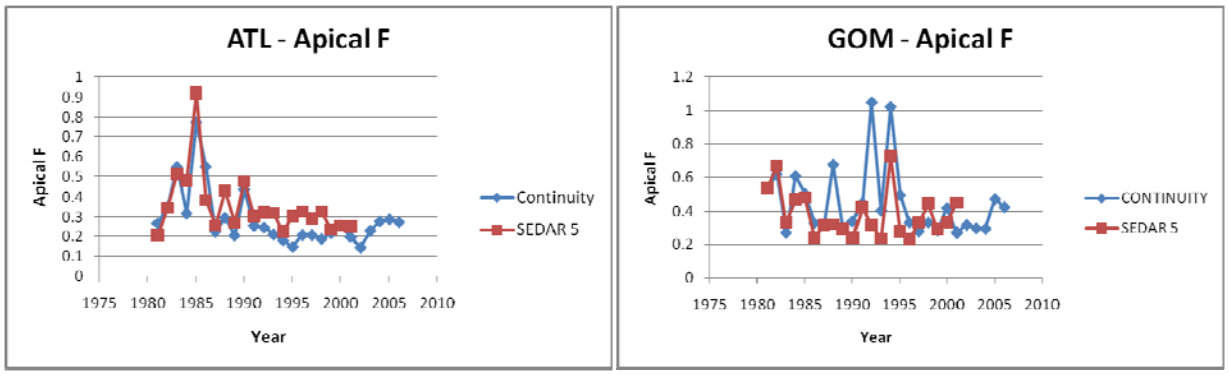

Figure 3.3. Comparison of annual fishing mortality estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run.

3.2 Status Quo mixing zone assumption

3.2.1 Estimated trends (recruits, SSB, F)

The VPA results include estimates of recruitment at age 0, spawning stock biomass and apical fishing mortality. Since catch-at-age was assumed to be known exactly, model uncertainty was determined by running 1000 non-parametric bootstraps of the index residuals. These bootstraps allow computation of upper and lower 80% confidence intervals on the annual estimates of SSB, R and F (shown in figures with dashed lines).

…….Recruitment

In the Atlantic, estimated recruitment at age-0 varies without obvious trend, ranging from 2 to 8.5 million (**Figure 3.4**). In the Gulf, recruitment at age-0 has varied substantially, ranging from 2 million in 1983 to 16 million in 2005 (**Figure 3.4**). During recent years recruitment has been quite high, averaging 14 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.

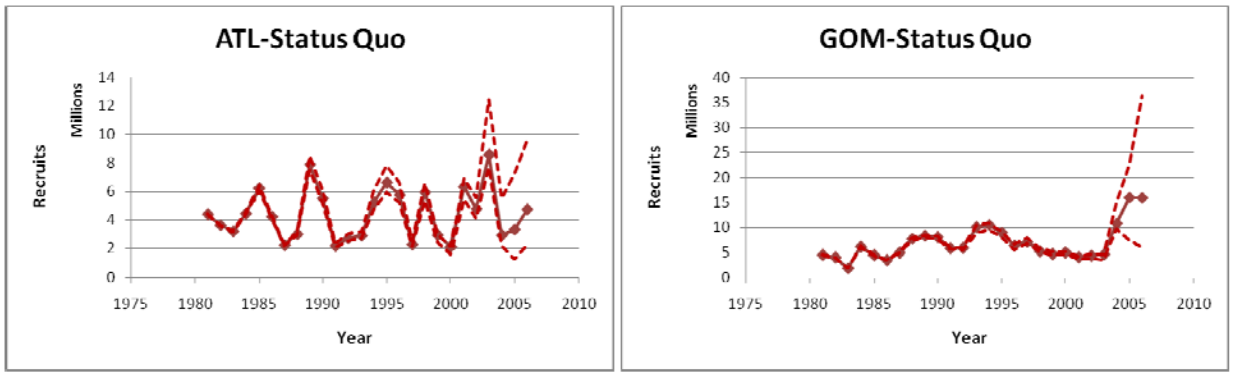

Figure 3.4. Annual trend in recruitment (Age-0) for "status quo mixing assumption" models. Upper and lower 80% confidence intervals are indicated with dashed lines.

…….*Spawning Stock*

According to the "status quo mixing assumption run, spawning stock in the Atlantic is larger than that in the Gulf (**Figure 3.5**). In the Atlantic, the spawning stock decreased somewhat before 1995, then began a slow increase. In the Gulf a more consistent and noticeable increase in spawning stock occurred through 2001. Since then, the stock has declined somewhat.

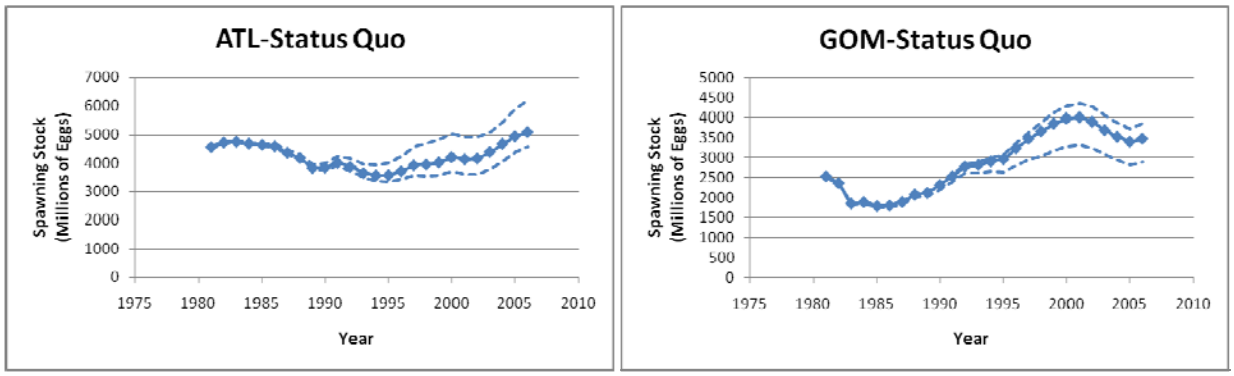

Figure 3.5. Annual trend in spawning stock (millions of eggs) for "status quo mixing assumption" models. Upper and lower 80% confidence intervals are indicated with dashed lines.

…….*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 (**Figure 3.6**). In the Atlantic, the highest fishing mortality rate occurred

in 1985 (0.44). Since then, fishing mortality has generally decreased. During recent years (2004-2006), the average apical F was estimated to be 0.16. In the Gulf, the highest fishing mortality occurred in 1982 (0.98). During 1982-1997, apical F varied without obvious trend, ranging from 0.74 to 0.24. This period was followed by several years of constant low fishing morality (0.24). However, since 2002 the apical F has increased substantially. During recent years (2004-2006), the average apical F was estimated to be 0.39.

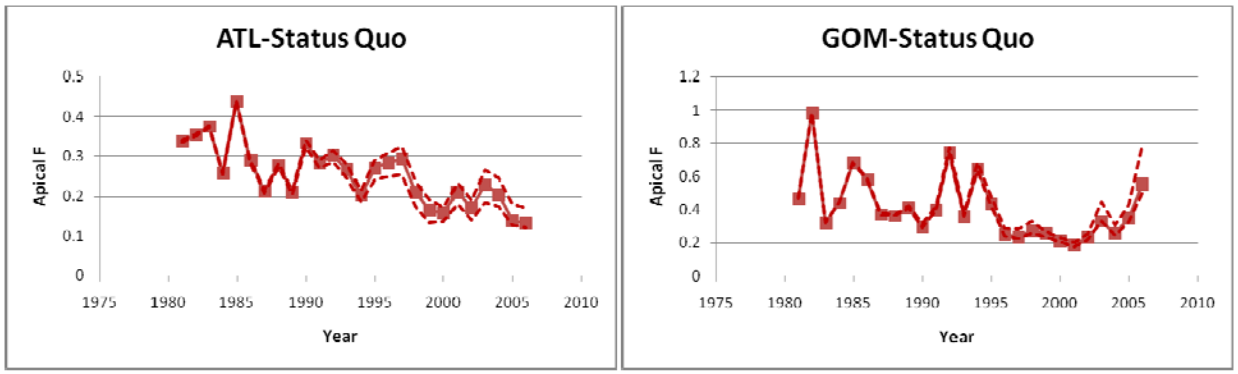

Figure 3.6. Annual trend in apical fishing mortality for "status quo mixing assumption" models. Upper and lower 80% confidence intervals are indicated with dashed lines.

The estimated terminal year (2006) fishing mortality rates at age for the "status quo mixing assumption" models are shown in **Figure 3.7**. These parameters were estimated for ages 0-10. The plus group (11+) terminal F was fixed at the estimated value for age 10.

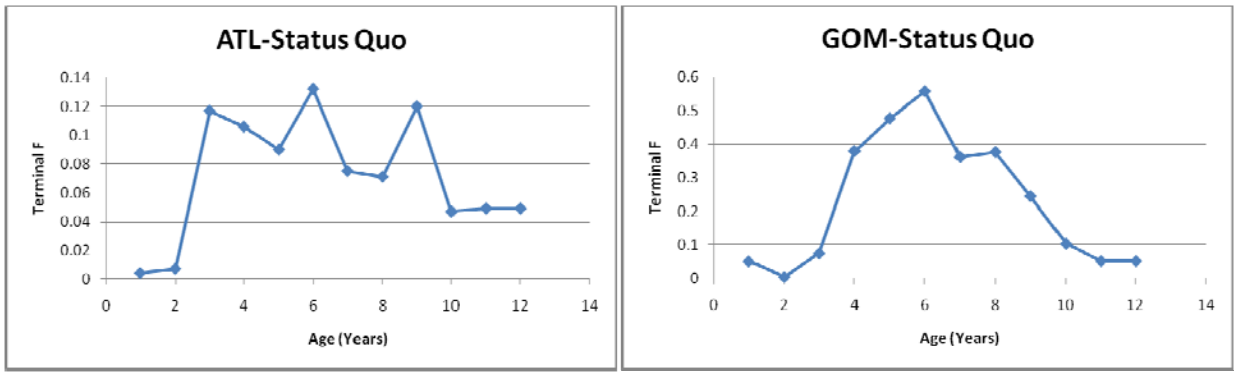

Figure 3.7. Terminal year (2006) fishing mortality-at-age for "status quo mixing assumption" models.

3.2.2 Diagnostics

To determine the "goodness of fit" for each VPA model, we produced the following diagnostics: likelihood statistics, fits to the indices of abundance and retrospective analyses.

Likelihood Statistics

Likelihood statistics including the objective function value, AIC, AICC, BIC and the log-likelihoods for the abundance indices are summarized in **Table 3.1.** The "status quo mixing assumption" models did not incur any out-of-bounds penalties. The non-zero value for the constraint on terminal F is caused by a penalty applied to limit changes in vulnerability during recent years (2004-2006, Ages 3-9, SD=0.4).

Table 3.1. Likelihood Statistics for "status quo mixing assumption" models.

Model	ATL-Status Quo	GOM-Status Quo
Total objective function	-63.03	-81.09
(with constants)	24.27	16.31
Number of parameters	21	21
Number of data points	95	106
AIC	90.55	74.63
AICC	103.2	85.63
BIC	144.18	130.56
Chi-square discrepancy	124.59	86.05
Loglikelihoods (deviance)	56.68	73.89
effort data	56.68	73.89
Log-posteriors	0	0
catchability	0	0
f-ratio	0	0
natural mortality	0	0
mixing coeff.	0	0
Constraints	6.34	7.2
terminal F	6.34	7.2
stock-rec./sex ratio	0	0
Out of bounds penalty	0	0
Log Likelihoood: Indices of Abundance	56.69	73.89
Index 1	20.97	25.08
Index 2	22.59	25.16
Index 3	-2.57	23.81
Index 4	13.75	-8.14
Index 5	1.95	7.98

Index Fits

The fits to the abundance indices are summarized in **Figures 3.8 and 3.9**. In the Atlantic, the fits to the commercial indices are quite good while the fits to the recreational indices and the SEAMAP South Atlantic Trawl survey are not as close (**Figure 3.8)**. This behavior occurs because the coefficients of variation (CVs) were used to estimate index variance. The CVs of the commercial indices are smaller than the other series, and the MRFSS index has the largest CVs (**Table. 2.16).**

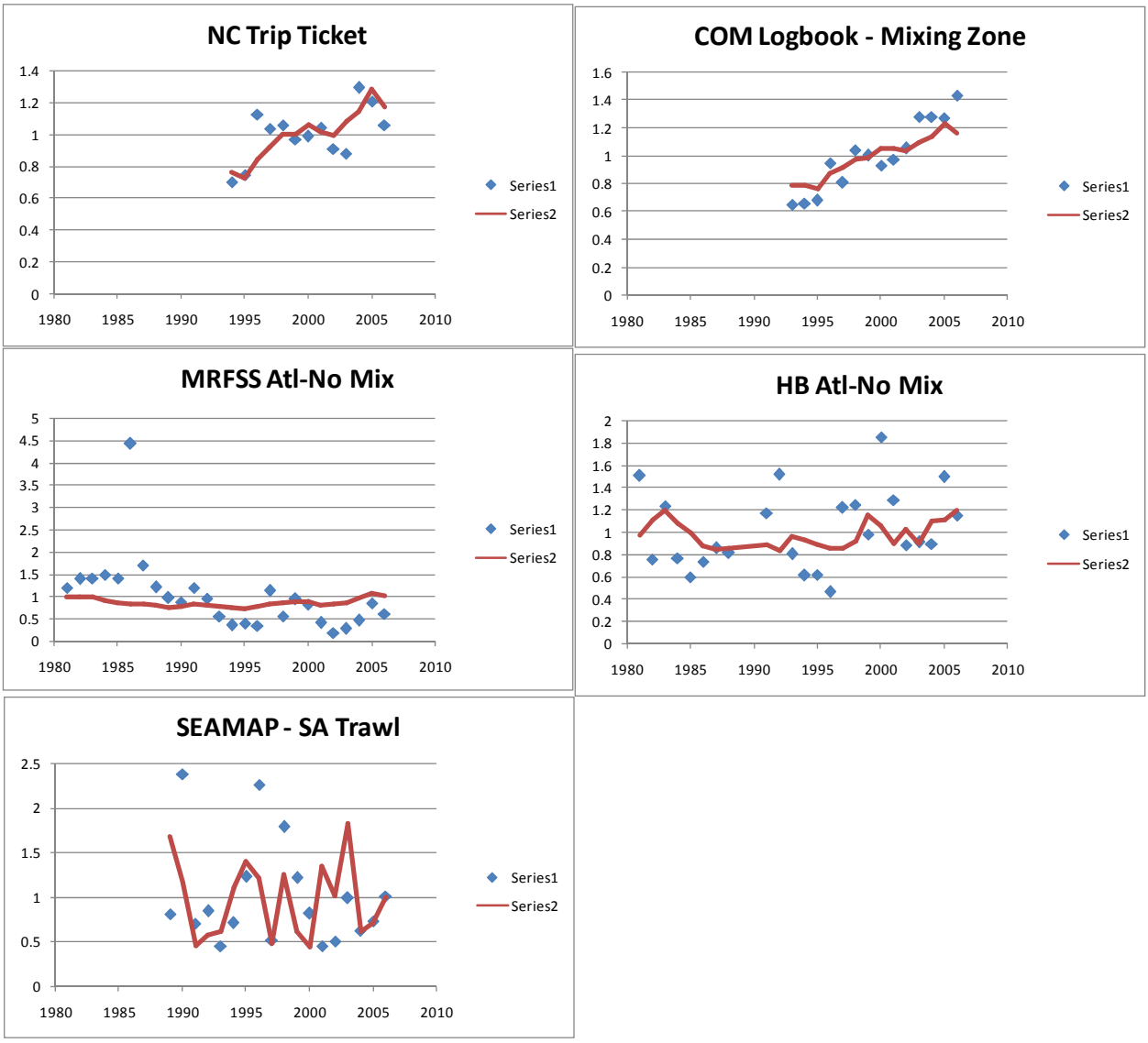

Figure 3.8. Fits to indices of abundance for Atlantic "status quo mixing assumption" model.

In the Gulf, the indices of abundance are generally fit well **(Figure 3.9)**, with the possible exception of the SEAMAP groundfish survey which has larger than average CVs. (**Table. 2.16)**.

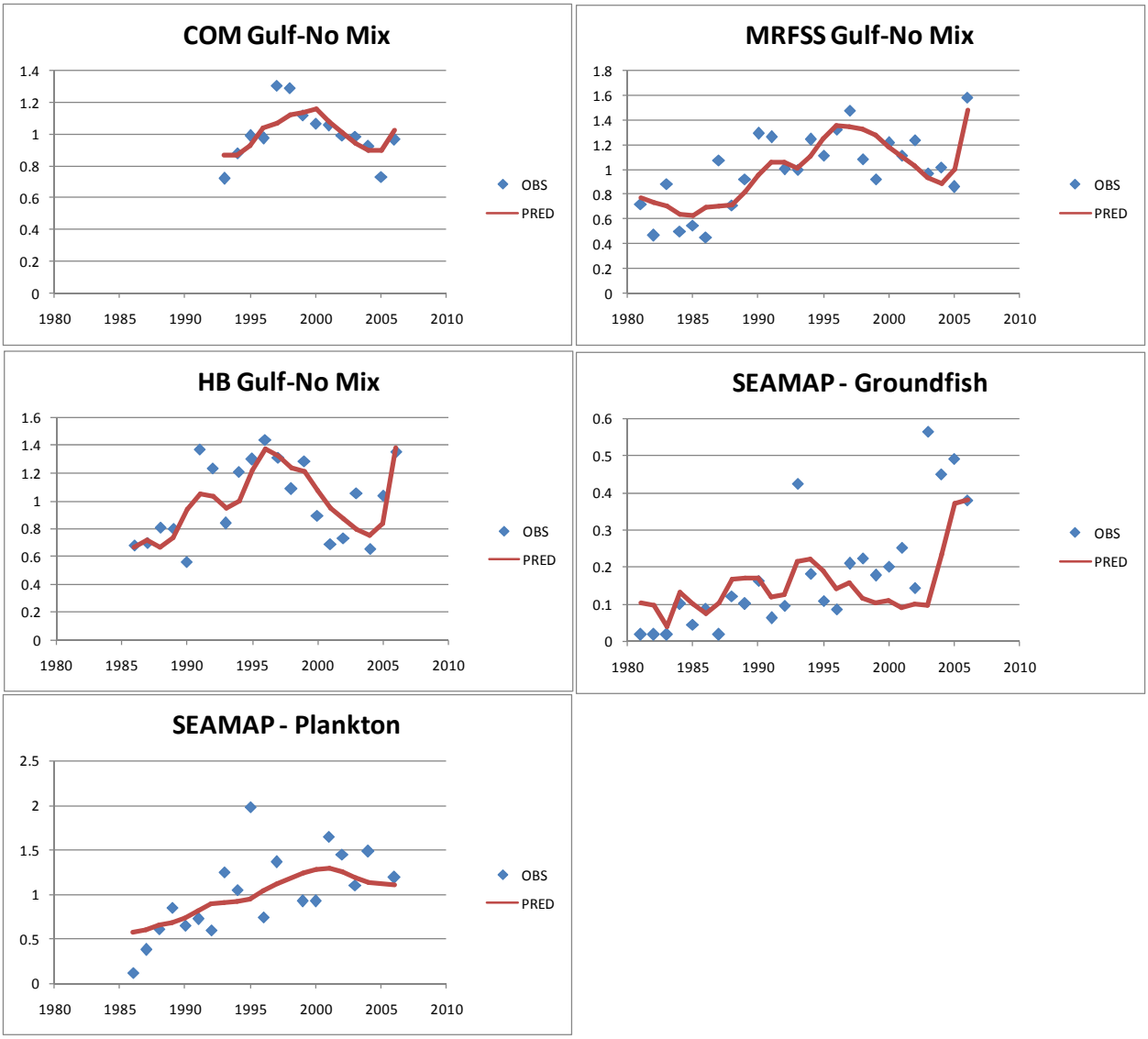

Figure 3.9. Fits to indices of abundance for Gulf "status quo mixing assumption" model.

Retrospective Patterns

Retrospective analyses are summarized in **Figure 3.10 and 3.11**. In the Atlantic (**Figure 3.10**), there are noticeable retrospective patterns in the annual estimates of SSB and R. The SSB estimates after 1987 depend on the terminal year of the model. In general, as years of data

were removed from the model, the SSB estimates tended to decrease in magnitude. An exception was the model run with the terminal year of 2001. That model had the highest estimates of SSB. This pattern seems to be caused by the recruitment estimates which also show some retrospective patterns, likely due to the systematic removal of annual index estimates from the SEAMAP South Atlantic Trawl Survey.

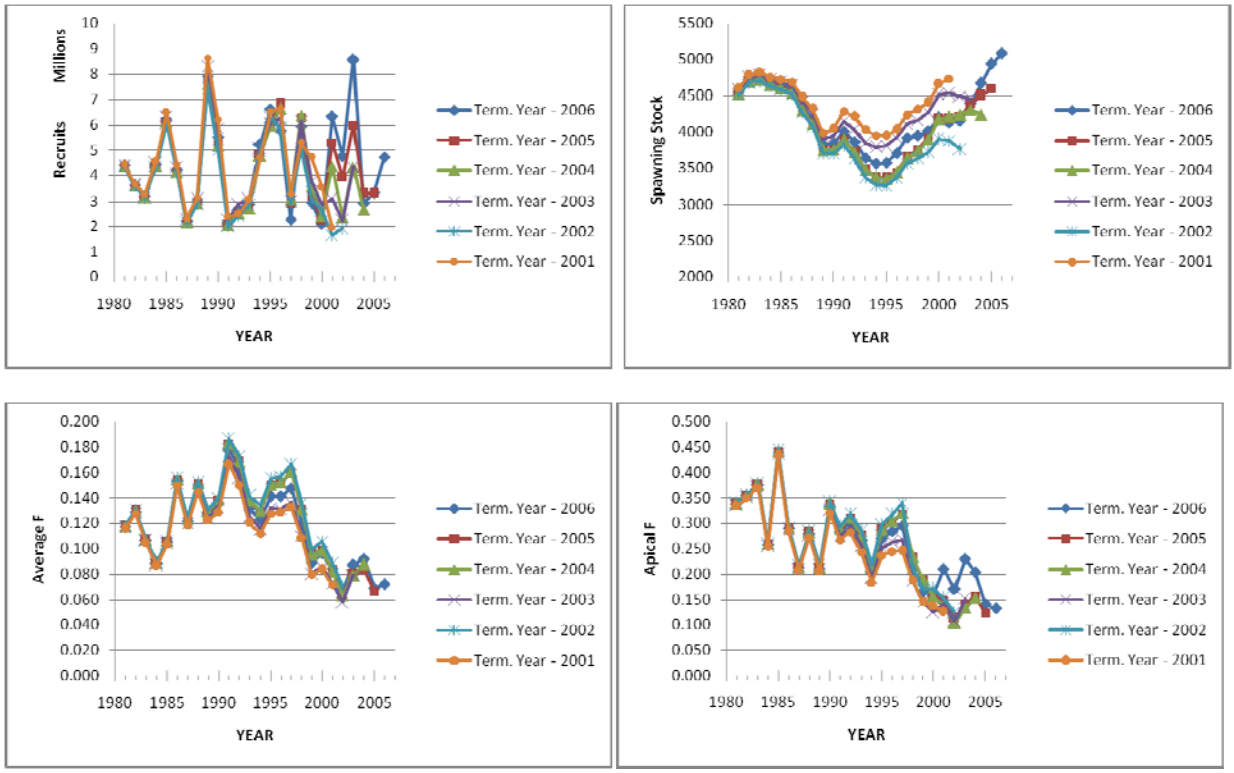

Figure 3.10. Retrospective patterns in recruitment (Age 0), spawning stock (millions of eggs), average F and apical F (max F-at-age) for the Atlantic "status quo mixing assumption" model.

In the Gulf (**Figure 3.11**), there are substantial retrospective patterns in the annual estimates of SSB and R. As years of data were removed from the model, the SSB estimates increased in magnitude. This pattern is caused by the recruitment estimates which also show strong retrospective patterns due to the systematic removal of annual index estimates from the SEAMAP Groundfish survey and Shrimp Bycatch estimates (age -0).

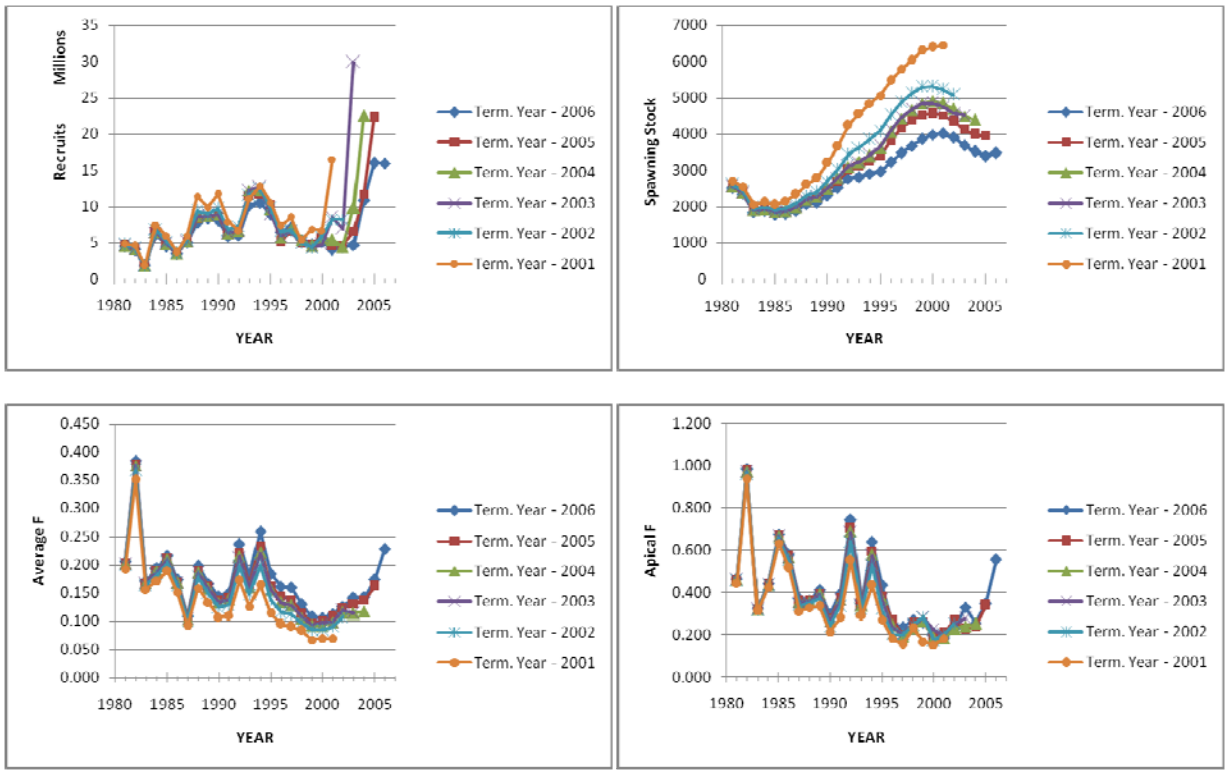

Figure 3.11. Retrospective patterns in recruitment (Age 0), spawning stock (millions of eggs), average F and apical F (max f-at-age) for the Gulf "status quo mixing assumption" model.

3.3 Updated VPA Model: Alternative 50/50 mixing zone assumption

3.3.1 Estimated trends (recruits, SSB, F)

VPA results include estimates of recruitment at age 0, spawning stock biomass and apical fishing mortality. Since catch-at-age was assumed to be known exactly, model uncertainty was determined by running 1000 non-parametric bootstraps of the index residuals. These bootstraps allow computation of upper and lower 80% confidence intervals on the annual estimates of SSB, R and F (shown in figures with dashed lines).

…….Recruitment

In the Atlantic, estimated recruitment at age-0 varied without obvious trend, ranging from 2.6 million in 1991 to 9.2 million in 2003 (**Figure 3.12**). In the Gulf, recruitment at age-0 has varied substantially, ranging from 1.6 million in 1983 to 14 million in 2006 (**Figure 3.12**). During recent years recruitment has been quite high, averaging 12 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.

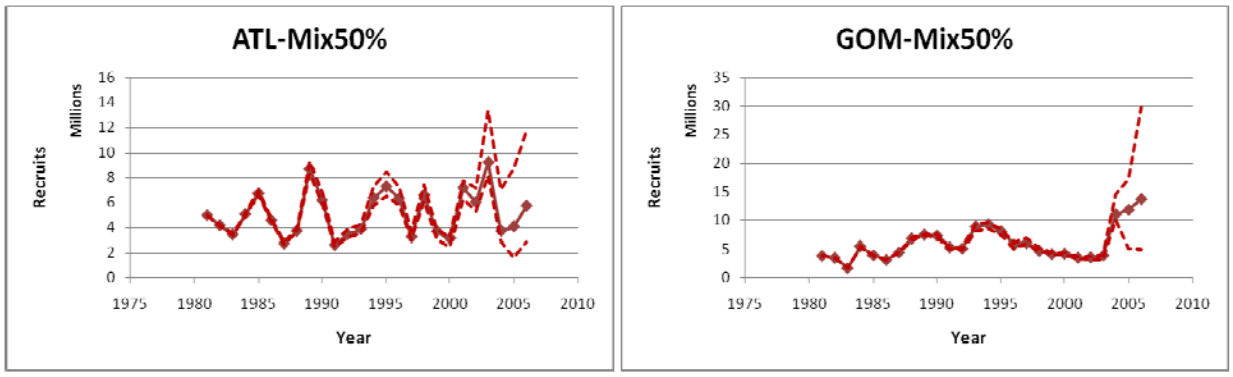

Figure 3.12. Annual trend in recruitment (Age-0) for "alternative 50/50 mixing assumption" models. Upper and lower 80% confidence intervals are indicated with dashed lines.

…….Spawning Stock

According to the "alternative 50/50 mixing run", spawning stock in the Atlantic is larger than that in the Gulf (**Figure 3.13**). In the Atlantic, the spawning stock decreased somewhat before 1995, then began a slow increase. In the Gulf a more consistent and noticeable increase in spawning stock occurred through 2001. Since then, the stock has declined somewhat.

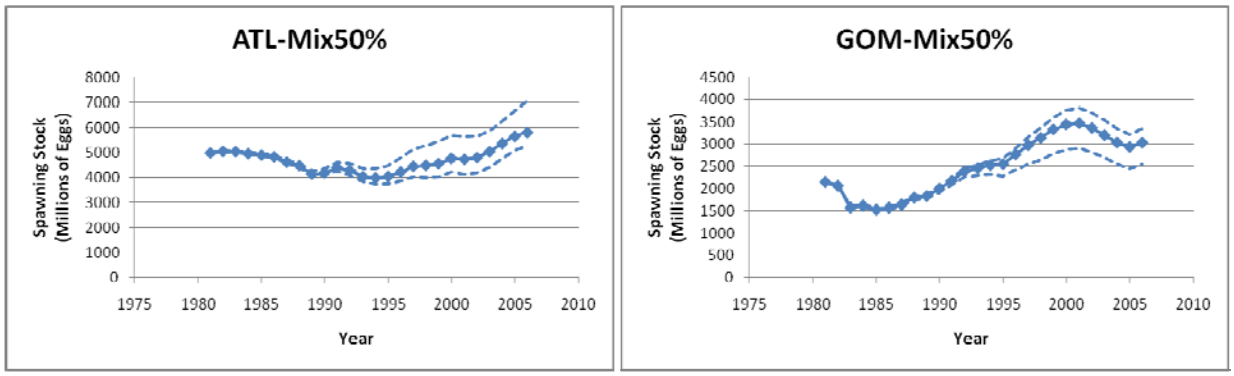

Figure 3.13. Annual trend in spawning stock (millions of eggs) for "alternative 50/50 mixing assumption" models. Upper and lower 80% confidence intervals are indicated with dashed lines.

…….Fishing Mortality

Annual trends in fishing mortality are summarized in **Figure 3.14**. In the Atlantic, the highest fishing mortality rate occurred in 1981 (0.44). Since then, fishing mortality has generally decreased. During recent years (2004-2006), the average apical F was estimated to be 0.15. In the Gulf, the highest fishing mortality occurred in 1982 (1.0). During 1982-1997, apical F varied without obvious trend, ranging from 0.68 to 0.24. This period was followed by several years of constant low fishing morality (0.24). However, since 2002 the apical F has increased substantially. During recent years (2004-2006), the average apical F was estimated to be 0.39.

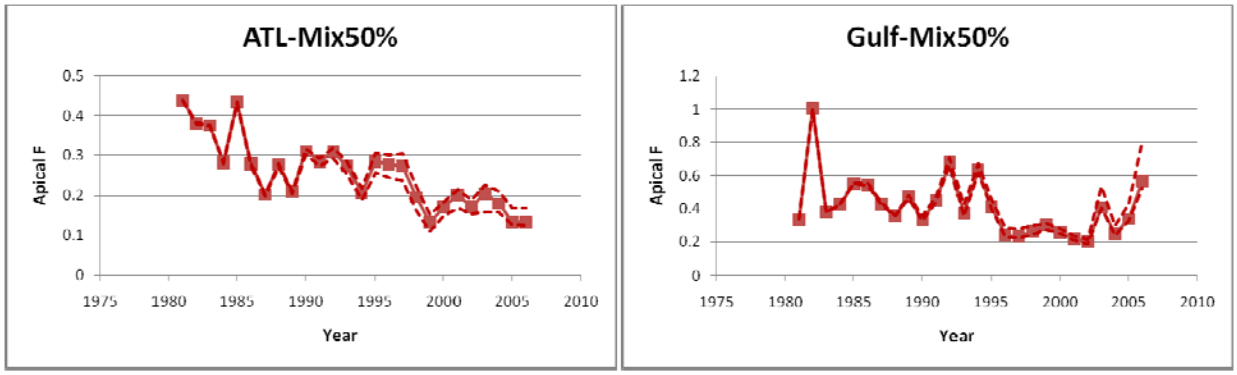

Figure 3.14. Annual trend in apical fishing mortality for "alternative 50/50 mixing assumption" models. Upper and lower 80% confidence intervals are indicated with dashed lines.

The estimated terminal year (2006) fishing mortality rates at age for the "alternative 50/50 mixing assumption" models are shown in **Figure 3.15**. These parameters were estimated for ages 0-10. The plus group (11+) terminal F was fixed at the estimated value for age 10.

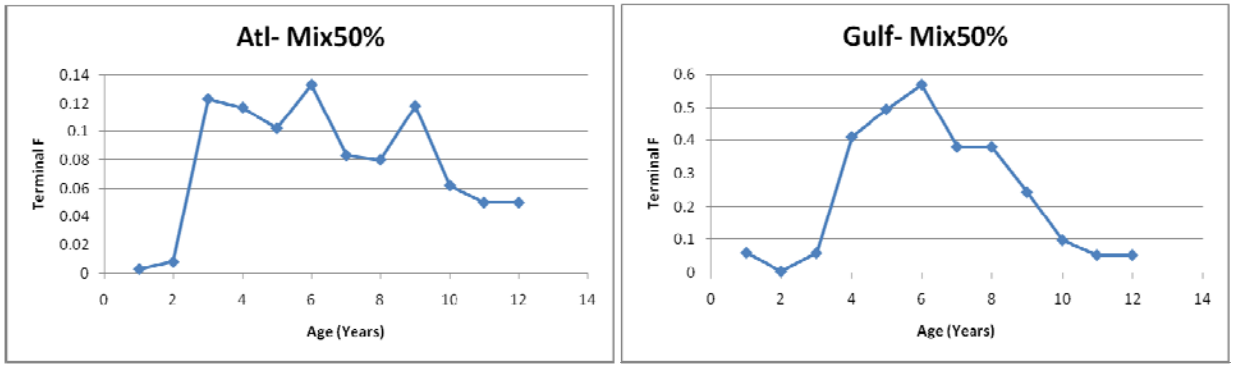

Figure 3.15. Terminal year (2006) fishing mortality-at-age for "alternative 50/50 mixing assumption" models.

3.3.2 Diagnostics

To determine the "goodness of fit" for each VPA model, we produced the following diagnostics: likelihood statistics, fits to the indices of abundance and retrospective analyses.

Likelihood Statistics

Likelihood statistics including the objective function value, AIC, AICC, BIC and the log-likelihoods for the abundance indices are summarized in **Table 3.2**. The "alternative 50/50 mixing assumption" models did not incur any out-of-bounds penalties. The non-zero value for the constraint on terminal F is caused by a penalty applied to limit changes in vulnerability during recent years (2004-2006, Ages 3-9, SD=0.4).

Table 3.2 Likelihood Statistics for "alternative 50/50 mixing assumption" models.

Model	ATL-Mix50%	GOM-Mix50%
Total objective function	-67.44	-80.45
(with constants)	19.86	16.96
Number of parameters	21	21
Number of data points	95	106
AIC	81.72	75.92
AICC	94.37	86.92
BIC	135.35	131.85
Chi-square discrepancy	101.93	88.1
Loglikelihoods (deviance)	58.66	73.29
effort data	58.66	73.29
Log-posteriors	0	0
catchability	0	0
f-ratio	0	0
natural mortality	0	0
mixing coeff.	0	0
Constraints	8.78	7.16
terminal F	8.78	7.16
stock-rec./sex ratio	0	0
Out of bounds penalty	0	0
Log Likelihoood: Indices of Abundance	58.67	73.3
Index 1	21.06	24.88
Index 2	23.98	25.03
Index 3	-2.96	23.84
Index 4	14.23	-8.33
Index 5	2.36	7.88

Index Fits

The fits to the abundance indices are summarized in **Figures 3.16 and 3.17**. In the Atlantic, the fits to the commercial indices are quite good while the fits to the recreational indices and the SEAMAP South Atlantic Trawl survey are not as close. This behavior occurs because the coefficients of variation (CVs) were used to estimate index variance. The CVs of the commercial indices are smaller than the other series, and the MRFSS index has the largest CVs (**Table. 2.16).**

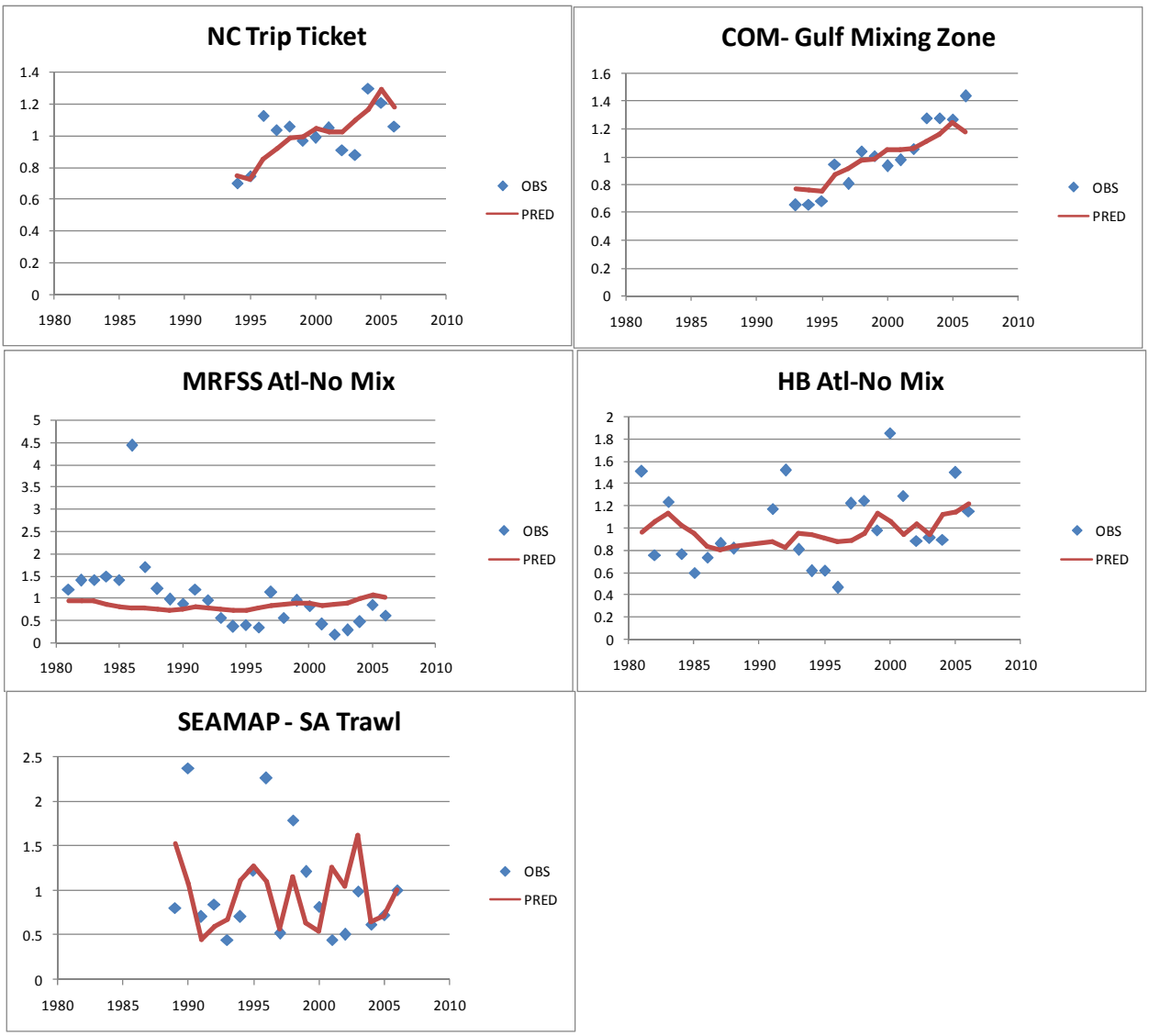

Figure 3.16. Fits to indices of abundance for Atlantic "alternative 50/50 mixing assumption" model.

In the Gulf, the indices of abundance are generally fit well **(Figure 3.17)**, with the possible exception of the SEAMAP groundfish survey which has larger than average CVs. (**Table. 2.16)**.

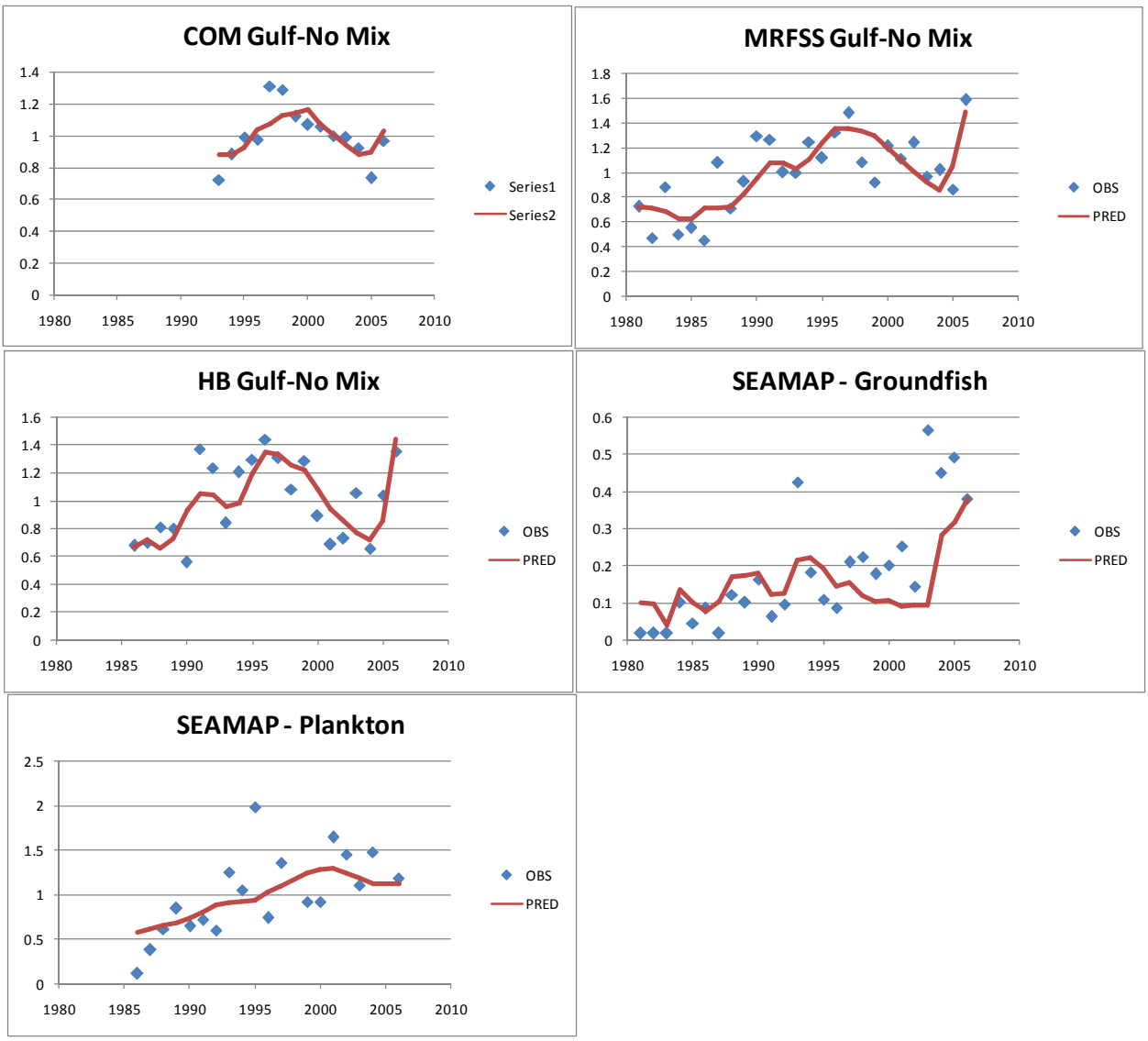

Figure 3.17. Fits to indices of abundance for Gulf "alternative 50/50 mixing assumption" model.

alternative 50/50

Retrospective Patterns

Retrospective analyses are summarized in **Figure 3.18 and 3.19**. In the Atlantic (**Figure 3.18**), there are noticeable retrospective patterns in the annual estimates of SSB and R. The SSB estimates after the mid-1980s depend on the terminal year of the model. In general, as years of data were removed from the model, the SSB estimates tended to decrease in magnitude. An exception was the model run with the terminal year of 2001. That model had the highest estimates of SSB. This pattern seems to be caused by the recruitment estimates which also

show some retrospective patterns, likely due to the systematic removal of annual index estimates from the SEAMAP South Atlantic Trawl Survey.

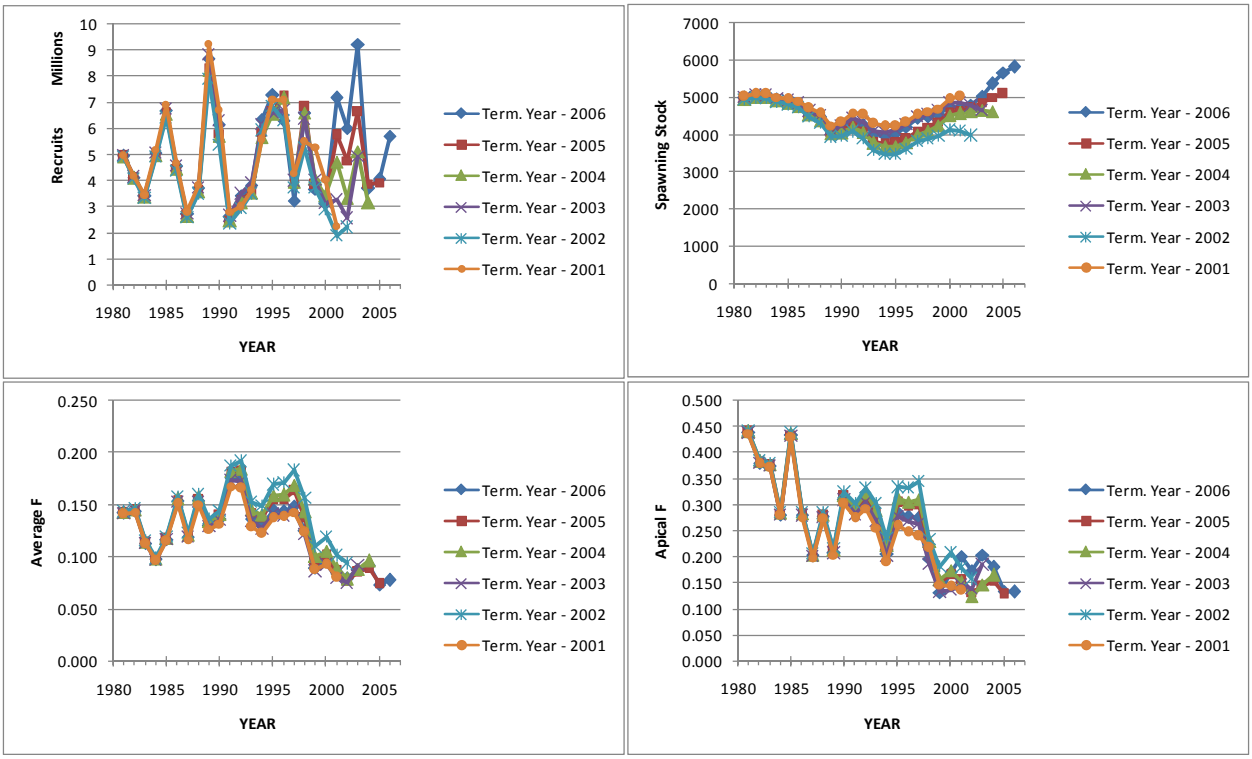

Figure 3.18. Retrospective patterns in recruitment (Age 0), spawning stock (millions of eggs), average F and apical F (max F-at-age) for the Atlantic "alternative 50/50 mixing assumption" model.

In the Gulf (**Figure 3.19**), there are strong retrospective patterns in the annual estimates of SSB and R. As years of data were removed from the model, the SSB estimates increased in magnitude. This pattern is caused by the recruitment estimates which also show strong retrospective patterns due to the systematic removal of annual index estimates from the SEAMAP Groundfish survey and Shrimp Bycatch estimates (age -0).

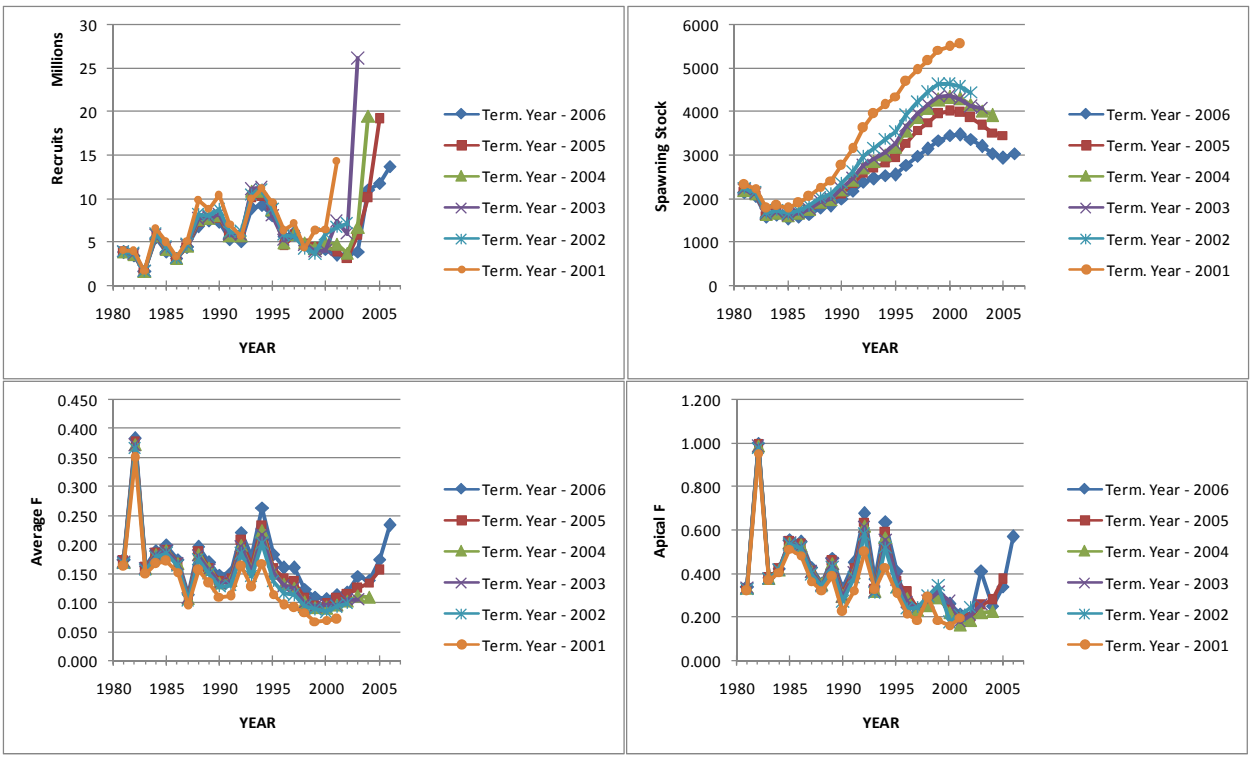

Figure 3.19. Retrospective patterns in recruitment (Age 0), spawning stock (millions of eggs), average F and apical F (max F-at-age) for the Gulf "alternative 50/50 mixing assumption" model.

4. Reference points / Benchmarks

This section summarizes how the various reference points and benchmarks have been calculated for king mackerel in the last assessment and provides updated estimates. Section 4.3 also provides some comments and suggests potential alternatives that could be considered.

4.1 Review of current usage

Following the 1998 NMFS Guidelines on National Standard 1 of the Magnuson-Stevens Fishery Conservation Management Act, the GMFMC and SAFMC defined a Maximum Fishing Mortality Threshold (MFMT) and a Minimum Stock Size Threshold (MSST) according to the default guidance provided in Restrepo et al. (1998): At high stock sizes, close to B_{MSY} and higher, MFMT = F_{MSY} = $F_{30\%}$. B_{MSY} was calculated from the replacement line corresponding to F30% that intersects the expected level of recruitment is a spawner-recruit plot. The MSST was calculated as (1-M)*B_{MSY}. In terms of a target Optimum Yield, a target of F40% has been used for computing ABC.

The following treatments of the data and assumptions have been used:

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: This follows a "hockey stick", or two-line relationship, where recruitment is constant at high stock sizes and decreases linearly to the origin below an SSB hinge point. The data used are all SSB-recruit pairs starting in the year for which there is relative abundance information for recruitment, and the last two years are left out of the computations (1981 and 1989 for the Gulf and Atlantic stocks, respectively).

Maximum average recruitment: This is the arithmetic mean recruitment for the years considered in the analyses.

SSB hinge: This is the arithmetic mean SSB for the five lowest SSB values in the years considered.

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

Life history parameters: These are used to maintain consistency with the VPA (i.e., the same natural mortality, fecundity and maturity vectors).

B_{MSY}: Specified by where the F30% replacement line intersects the expected stock-recruitment relationship.

4.1.1 Results

Table 4.1 Shows the life-history inputs for the per-recruit computations. Table 4.2 shows the estimated mean recruitments and SSB hinge points derived from the VPA results. Table 4.3 summarizes the per-recruit calculations, contrasted to the current fishing mortality.

Table 4.1 Inputs used for the per-recruit computations.

GULF					100-0	50-50
Age	**Weight**	**Fecund**	**Mature**	**M**	**Sel**	**Sel.**
0	1.094	0.000	0.000	0.611	0.489	0.604
1	1.981	0.155	0.157	0.274	0.050	0.051
2	3.017	0.267	0.529	0.243	0.587	0.543
3	4.123	0.395	0.704	0.222	0.918	0.921
4	5.236	0.531	0.856	0.207	1.000	1.000
5	6.310	0.669	0.989	0.196	0.809	0.820
6	7.315	0.801	1.000	0.188	0.642	0.648
7	8.236	0.926	1.000	0.182	0.506	0.500
8	9.064	1.041	1.000	0.177	0.344	0.348
9	9.800	1.145	1.000	0.173	0.245	0.247

10	10.446	1.238	1.000	0.170	0.186	0.197
11+	11.009	1.524	1.000	0.162	0.186	0.197

ATL.					100-0	50-50
Age	**Weight**	**Fecund**	**Mature**	**M**	**Sel**	**Sel.**
0	0.795	0.000	0.000	0.539	0.020	0.017
1	1.795	0.130	0.548	0.256	0.056	0.066
2	3.000	0.250	0.861	0.220	0.570	0.716
3	4.253	0.388	0.924	0.199	0.621	0.740
4	5.450	0.528	0.948	0.186	0.749	0.816
5	6.531	0.662	0.970	0.176	1.000	1.000
6	7.471	0.783	0.989	0.170	0.832	0.858
7	8.267	0.890	1.000	0.165	0.697	0.725
8	8.929	0.981	1.000	0.161	0.673	0.684
9	9.470	1.058	1.000	0.158	0.390	0.430
10	9.910	1.123	1.000	0.156	0.328	0.333
11+	10.263	1.288	1.000	0.152	0.328	0.333

Table 4.2 Estimated values for the two-line stock/recruit relationships estimated for king mackerel from various VPA runs.

Group	Mixing	Years Used	All years Mean R	Five low Mean SSB
Atlantic	100-0	1989-2004	4,656,412	3,661,800
	50-50	1989-2004	5,456,918	4,062,600
Gulf	100-0	1981-2004	6,141,495	1,837,400
	50-50	1981-2004	5,432,537	1,593,000

Table 4.3. Estimated benchmarks from per-recruit computations. The tables show the level of fishing mortality (using the selectivity from the last 5 years), the level of eggs per recruit (S/R), the level of yield per recruit (Y/R), and the equilibrium S corresponding to the mean recruitment levels reported in Table 4.2

Gulf 100-0	**F**	**S/R**	**Y/R**	**S**
Fcurrent	0.295	0.500196	0.9384	3071951
F30%	0.28	0.527705	0.922786	3240897
F40%	0.205	0.703606	0.813437	4321194
Gulf 50-50	**F**	**S/R**	**Y/R**	**S**
Fcurrent	0.286	0.502138	0.927249	2727883
F30%	0.273	0.527705	0.913046	2866777

F40%	0.2	0.703606	0.805743	3822366
Atl 100-0	**F**	**S/R**	**Y/R**	**S**
Fcurrent	0.142	1.170592	0.860632	5450758
F30%	0.351	0.639093	1.233703	2975881
F40%	0.239	0.852115	1.101415	3967798
Atl 50-50	**F**	**S/R**	**Y/R**	**S**
Fcurrent	0.141	1.123562	0.886223	6131183
F30%	0.317	0.639097	1.218532	3487497
F40%	0.219	0.852123	1.086826	4649965

Figure 4.1 Shows the estimated SSB-recruit points from the VPAs and the estimated two-line relationships. Note that the F30% replacement lines do not intersect the expected stock-recruitment relationship for the Atlantic stock. This leads to an inconsistency. On the one hand, the VPAs and per-recruit computations for the Atlantic suggest that the stock is lightly exploited (current F about one half the magnitude of F30%); on the other hand, the prescribed stock-recruitment relationship indicated that any fishing which drives the biomass below the lowest observed values is unsustainable.

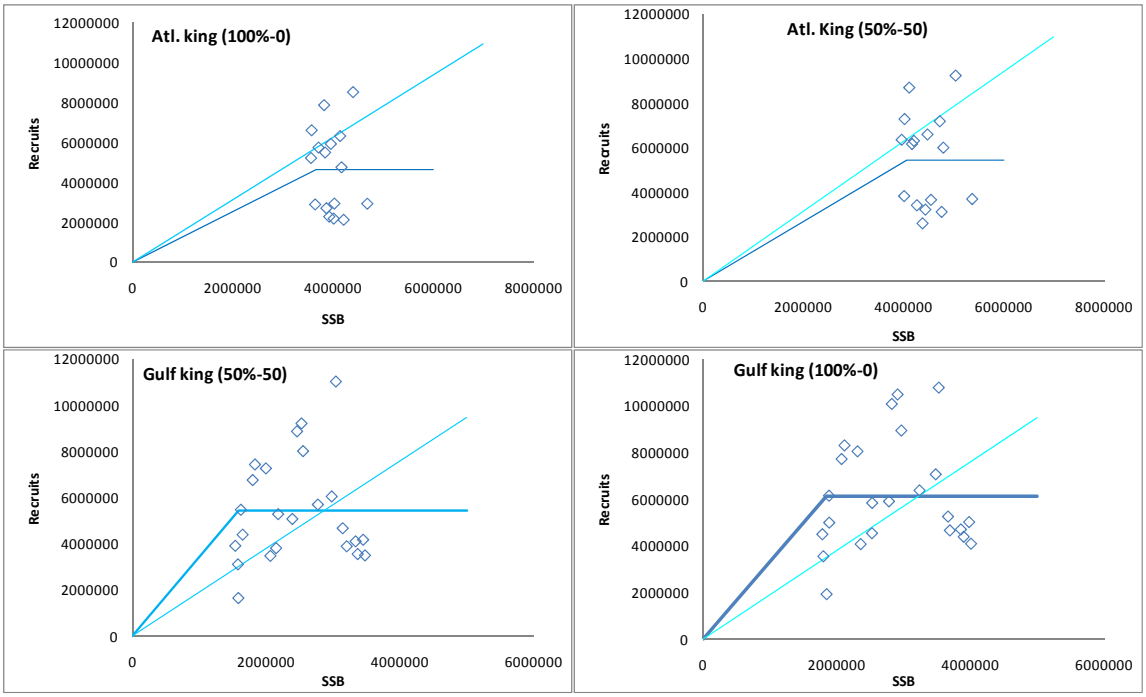

Figure 4.1 Estimated SSB-recruit points from the VPAs (only data pairs used in the calculations are shown) and the estimated two-line relationships. The straight line through the origin is the F30% replacement line; its intersection with the horizontal expected recruitment line defines SSB_{MSY}.

Figure 4.2 shows the relative trends in SSB and F, expressed relative to F30%.

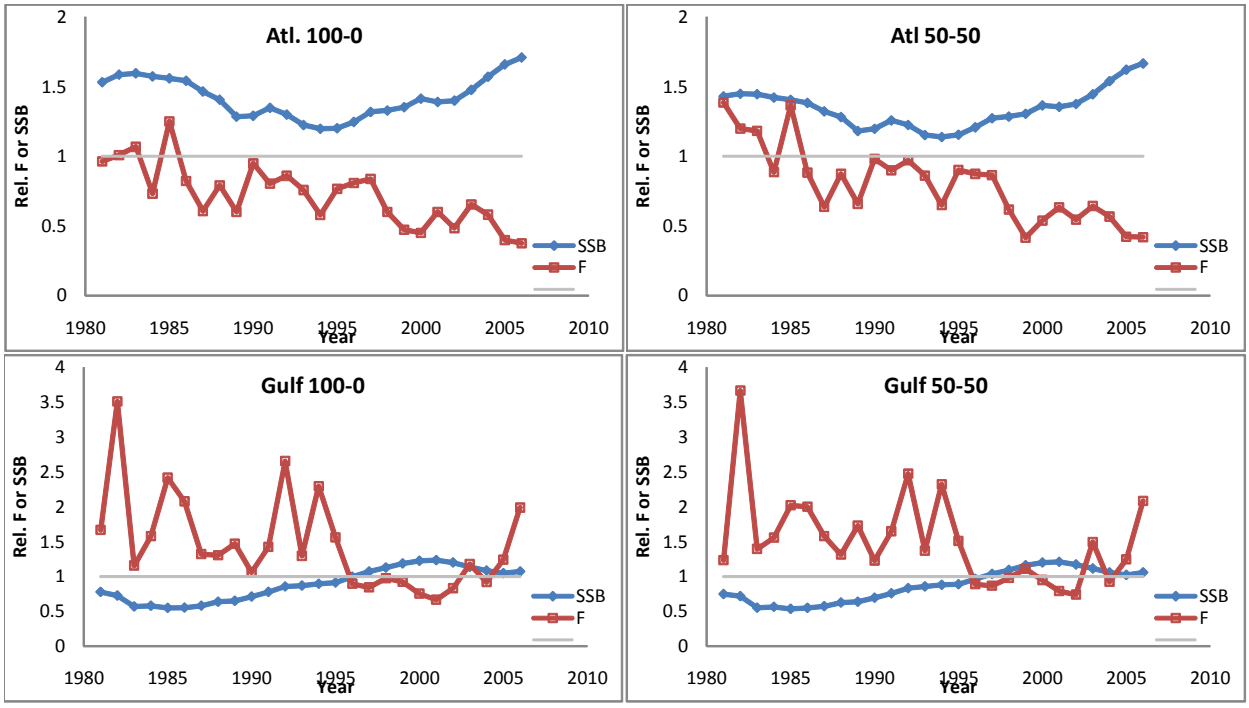

Figure 4.2 Estimated trends in SSB and fishing mortality relative to F30% levels (FMSY proxy) for various VPA runs.

4.2 Possible alternatives

As shown above, the estimation of a stock-recruitment relationship for the Atlantic migratory group that uses the same prescription as used in SEDAR 5 is problematic because the F30% replacement line fails to cross the expected relationship. Various factors may contribute to the fact that this behavior is observed now but was not during SEDAR 5, including the addition of new data such as catch and relative abundance for age 0 mackerel. One of the potential alternatives that could be considered is to allow recruitment to remain constant to some level below the lowest observed SSB. For example, estimate Bmsy as the intersection between the mean observed recruitment and the F30% replacement line, and allow recruitment to still remain constant down to a level of (1-M)*Bmsy. Another alternative would be to fit a stock-recruitment relationship with a prior for steepness.

The same problematic behavior was not observed for the Gulf stock. Nevertheless, the available SSB-recruitment data as well as fishery-independent indices of abundance suggest that a Beverton-Holt type of stock recruitment relationship could be considered (see Figure 4.3).

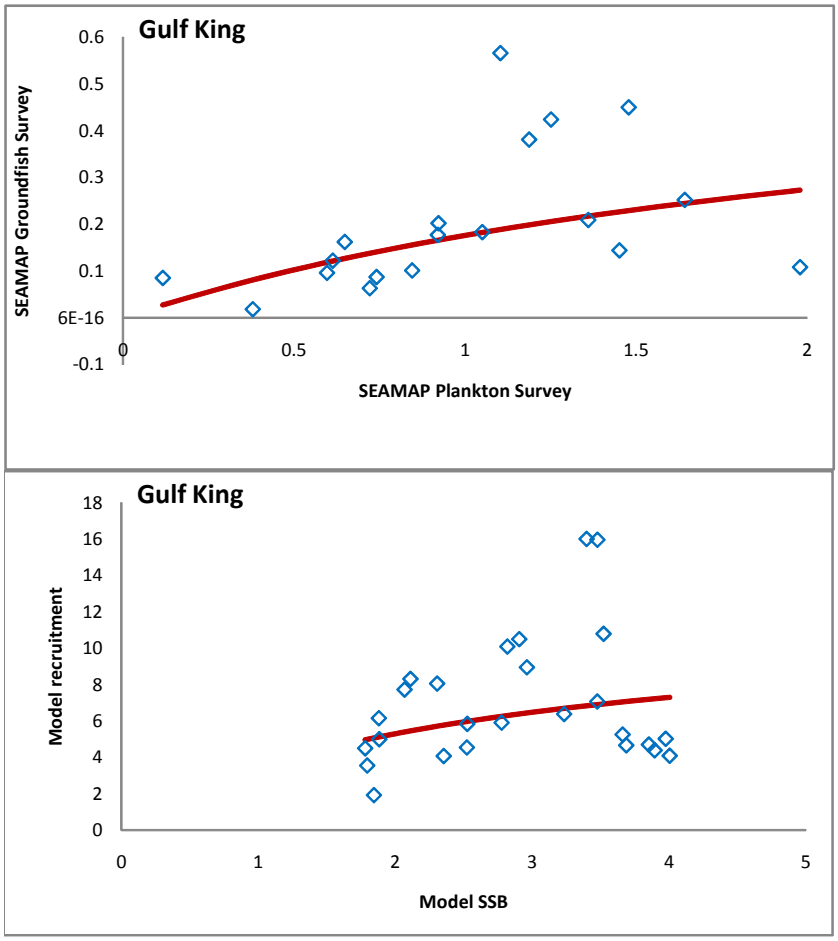

Figure 4.3. Top: empirical stock-recruitment relationship for Gulf king mackerel from fishery-independent indices. Bottom: Estimated stock-recruitment data from VPA (assuming 50-50% of the mixing zone fish are from the Gulf).

5. Conclusions

The main VPA runs presented in Sections 3.2 and 3.3 of this document appear to provide reasonable fits to the available data. One item that could potentially be explored more thoroughly is the fit to the fishery-independent indices. This could be achieved, for example, by considering different weightings for the indices that are not simply derived from the standardization modeling process.

One issue that will need to be addressed if the VPA results are used for management advice is how to model future recruitment, particularly for the Atlantic migratory group (see Section 4).

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