What if Mixing Area Fish are Assigned to the Atlantic Migratory Group Instead of the Gulf of Mexico Migratory Group?

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Summary

Currently there are two migratory groups of king mackerel recognized for assessment and management purposes, the Atlantic migratory group and the Gulf of Mexico migratory group. The boundary between these groups changes during the year. During the summer, the Monroe-Collier County, FL, border separates the landings assigned to the migratory groups while during the winter the Flagler-Volusia County, FL, border delimits the landings assigned to the migratory groups. The overlap between these two boundaries is known as the mixing area. It has been suggested that some king mackerel in the mixing area during the winter belong to the Atlantic group. In this document, all mixing area king mackerel landings are assigned to the Atlantic group and provides a basis for evaluating the results of stock assessments and projected allowable biological catches (ABC) for both the Atlantic group and the Gulf of Mexico migratory group king mackerel under this alternative. Results of the analysis indicated that under this scenario, the estimated Atlantic group population is larger, has a similar spawning potential ratio (SPR), and would support a larger ABC than if landings of mixing area fish are distributed between the Atlantic and Gulf of Mexico migratory groups as in the currently accepted assessment procedure. In contrast, the estimated Gulf of Mexico group population is smaller, has a more pessimistic trend in SPR and a lower ABC than when the mixing area fish are distributed between the Atlantic and Gulf of Mexico groups as in the currently accepted assessment procedure. The total ABC for king mackerel in the Atlantic and Gulf of Mexico combined, can either increase or decrease slightly depending upon which group is assigned the mixing area fish and which bycatch level is chosen for the Atlantic group. These results are consistent with results presented to previous MSAP meetings examining this question. Due to time constraints, a full analysis of the mixing area problem could not be conducted. Specifically, the catch per unit effort (CPUE) indices used to tune the virtual population analysis (VPA) were not recomputed based on the new group assignments relative to the two migratory groups and the ageing of fish caught in the mixing area was maintained in its current form.

Introduction

Currently there are two migratory groups of king mackerel recognized for management purposes, the Atlantic migratory group and the Gulf of Mexico migratory group. The boundary used for assigning landings to migratory groups changes during the year. During the summer (April 1 to October 31) the Monroe-Collier county line separates landings assigned to the groups while during the winter (November 1 to March 31) the Flagler-Volusia county line delimits the landings assigned to each group. The overlap caused by shifting the boundary is known as the mixing area. It has been suggested that at least some king mackerel in the mixing area during the winter actually belong to the Atlantic group, but the proportion has not been specified (see *i.e.* Sutter *et al.* 1991, Anonymous 1996). New research using otolith shape analysis has suggested there is a significant proportion of Atlantic migratory group fish caught in the mixing during the winter (Grimes and DeVries 1998). This work assigns mixing area fish to the Atlantic group and examines the results of the stock assessments and projected allowable biological catches (ABC) for both the Atlantic group and the Gulf of Mexico migratory group king mackerel under this alternative landings assignment scenario.

Methods

Due to time constraints only a simple approach to the problem could be considered. The fish caught in the mixing area were subtracted from the Gulf of Mexico group catch (Legault *et al.* 1998, MSAP/98/09) and added to the Atlantic group catch. The partial catch at age used to generate the selectivity patterns for the were also subtracted from the Gulf group and added to the Atlantic group as necessary. The number of fish caught in the mixing area is considerable relative to the number caught outside the mixing area (Table 1). The mixing area fish contribute approximately 25% of the total catch to whichever group they are assigned when averaged over all years and ages. Stock assessments were conducted using tuned virtual population analysis and projections made to estimate the allowable biological catch for the 1998/99 fishing season for the two groups following the standard procedure (see Legault *et al.* 1998, MSAP/98/09).

This simple approach ignores two issues potentially important to the interpretation of the results: 1) the ageing of fish in the mixing area and 2) the tuning indices used in the virtual population analyses. The ageing of fish in the mixing area is not a problem when sufficient age-length keys are available. The problem arises when the stochastic ageing procedure must be used due to missing or limited age-length keys (see Cummings 1989). The stochastic ageing procedure requires a growth equation and associated confidence interval to probabilistically assign fish lengths to ages. The different growth equations for the two groups means this assigning of ages will differ depending upon which growth equation is used. The tuning indices used in the virtual population analyses were not recomputed to reflect the change in group designation for the mixing area fish. Specifically, the Atlantic group FDEP, MRFSS and headboat CPUE indices and the Gulf of Mexico group charterboat in southwest Florida, MRFSS and headboat CPUE indices were not recomputed.

Results

Atlantic Group King Mackerel Including Mixing Area Fish

The Atlantic king mackerel virtual population tuning results using the Vaughan and Nance low bycatch estimates are given in Table 2a including parameter standard errors and

coefficients of variation, index fits, index selectivities, residual analyses, diagnostics, abundance at age and fishing mortality at age estimates. Tables 2b and 2c contain partial results from the other bycatch scenarios. Comparison of the observed and predicted indices are given in Figure 1. Population trends and unweighted transitional SPR from the Monte Carlo/bootstrap analyses are given in Figure 2. Probabilities of exceeding given SPR conditions under various yields in the 1998/99 fishing year are given in Table 3 and Figure 3. The allowable biological catches for the deterministic case and the median of the stochastic simulations under a range of management objectives (%SPR) are given in Tables 6-7.

Inclusion of mixing area fish in the Atlantic group caused estimates of population abundance to increase while estimates of fishing mortality rates remained about the same compared to analyses using the currently accepted procedure (see Legault *et al.* 1998, MSAP/98/09). Spawning potential ratio shows a slightly greater increasing trend when mixing area fish are included compared to the accepted procedure, but the uncertainty about the point estimates is much greater than the difference between the two lines. The 1998/99 fishing season projected allowable biological catch at 30% SPR increases between approximately 0.9 and 4.6 million pounds when the mixing area fish are included in the Atlantic group depending upon the level of bycatch used in the analyses.

Gulf of Mexico Group King Mackerel Without Mixing Area Fish

The Gulf of Mexico king mackerel virtual population tuning results are given in Table 4 including parameter standard errors and coefficients of variation, index fits, index selectivities, residual analyses, diagnostics, abundance at age and fishing mortality at age estimates. Comparison of the observed and predicted indices are given in Figure 4. Population trends and unweighted transitional SPR from the Monte Carlo/bootstrap analysis are given in Figure 5. Probabilities of exceeding given SPR conditions for this analysis under various yields in the 1998/99 fishing year are given in Table 5 and Figure 6. The projected allowable biological catches for the deterministic case and the median of the stochastic simulations under a range of management objectives (%SPR) are given in Tables 6-7.

Removal of mixing area fish from the Gulf of Mexico group caused estimates of population abundance to decrease while estimates of fishing mortality remained about the same. Spawning potential ratio shows a flatter, possibly even decreasing, trend when mixing area fish are removed, but the uncertainty about the point estimate is again much greater than the difference between the two lines. The 1998/99 fishing season projected allowable biological catch at 30% SPR decreases approximately 1.2 million pounds when mixing area fish are removed from the Gulf of Mexico group compared to the presently accepted assessment procedure (see Legault *et al.* 1998, MSAP/98/09). Thus, under this scenario, the total ABC (sum of projected ABC for both the Atlantic and Gulf of Mexico groups) can decrease 0.3 or increase 3.4 million pounds compared to the currently accepted procedure (see Legault *et al.* 1998, MSAP/98/09) depending upon the level of bycatch used in the analyses.

Literature Cited

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Table 1. Number of king mackerel caught in the mixing area and number caught outside the mixing area and assigned to the Atlantic group and the Gulf of Mexico group.

Catch in Mixing Area

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	22	10	21	5	8	5	137	4	0	488	2
1	1066	15474	179	5404	3288	10949	13957	9315	44139	20148	11767
2	2913	23415	21936	6533	8449	10857	55252	17651	42921	37932	50455
3	22252	46194	113848	17242	14814	44627	34912	16267	16099	104293	61063
4	361364	108755	42831	85631	42410	47953	20767	76691	10077	27677	31076
5	55520	112733	11534	58733	45858	15890	6311	37340	6744	1148	6636
6	9527	983	14911	12680	15885	4267	2037	11069	4230	7728	13267
7	12928	6615	9349	19306	1743	3043	4858	3626	2149	2599	3760
8	3766	3136	4761	187	222	350	189	3562	1371	947	1192
9	1547	343	514	3	877	57	19	1310	1165	224	1100
10	1289	808	869	652	556	35	85	5	2433	225	1272
11+	1110	1158	836	701	2015	174	93	1768	3450	2764	5938
sum	473304	319624	221588	207077	136125	138207	138617	178607	134779	206173	187529

age	92/93	93/94	94/95	95/96	96/97
0	2	0	10	339	7
1	11761	23717	9125	17318	4010
2	28255	36175	19008	48509	118821
3	52618	22679	38080	43429	62716
4	41537	24263	31772	8591	27693
5	27634	14037	43622	39784	33745
6	6489	7409	18894	14379	3262
7	7722	5670	2663	19537	4048
8	14828	7200	6608	1691	9963
9	10594	3451	7294	2734	2489
10	4093	2330	1901	1257	162
11+	14589	3609	4393	3372	2500
sum	220122	150541	183372	200940	269417

Table 1. Number of king mackerel caught in the mixing area and number caught outside the mixing area and assigned to the Atlantic group and the Gulf of Mexico group (cont.).

Atlantic Group Catch (no mixing area fish)

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	589	2809	3693	1175	1117	1441	6151	1757	997	608	243
1	5854	5519	29287	4165	86459	118293	197819	19394	69084	134813	95988
2	14335	5750	60259	10079	126498	221907	212012	217480	101676	162794	321248
3	55954	20653	100524	19651	25568	115697	139893	192579	137946	78594	103736
4	154113	72035	70141	102212	64835	141440	95072	113240	98881	91287	70365
5	131163	170070	138440	135161	98826	63702	73755	60041	69187	81532	99802
6	101579	168341	72811	119135	133340	62910	40807	60993	45231	60087	83573
7	134702	163125	128809	143957	168219	92827	33794	62595	31705	26524	45919
8	52511	154633	137135	54025	201313	56918	23014	22416	16741	15597	30852
9	72985	27181	68940	67192	59323	17873	13912	46998	9812	27181	11985
10	21095	2197	31200	57805	18480	26756	11902	21218	41949	14470	8084
11+	27268	119087	64689	79610	67229	57397	43636	77820	40376	56011	62225
sum	772148	911400	905928	794167	1051206	977160	891765	896530	663585	749500	934019

age	92/93	93/94	94/95	95/96	96/97
0	546	1081	3	59	941
1	77386	48764	90443	114194	33373
2	259453	85149	140721	154476	153885
3	279931	129163	64185	90254	133296
4	70900	110448	75289	59067	100942
5	43701	32380	88968	48155	65170
6	52411	34361	42433	85887	49648
7	46267	34026	15378	10216	65256
8	18954	42321	20874	18488	31835
9	18360	18569	32298	24794	27903
10	12191	17947	13322	19049	6759
11+	62402	45917	23653	18985	30655
sum	942501	600127	607567	643625	699663

Table 1. Number of king mackerel caught in the mixing area and number caught outside the mixing area and assigned to the Atlantic group and the Gulf of Mexico group (cont.).

Gulf of Mexico Group Catch (no mixing area fish)

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	43	9431	61	33	489	3571	1230	766	2292	6517	2216
1	380	7048	189	1265	7358	66716	50778	30058	176419	58381	203774
2	4329	159858	107410	3853	33178	167990	112448	105530	148181	161481	257304
3	43125	89753	144717	166613	24251	55896	43922	65386	81335	119201	127469
4	210747	216219	123278	201255	148419	84596	22828	114025	61939	50854	93770
5	132014	174323	37869	68777	104485	22488	20674	30004	30858	38547	26645
6	38601	90752	54189	41126	64685	29323	13769	50927	11000	26921	21064
7	19291	58019	19479	16079	16217	17176	5769	25747	18865	12002	9721
8	11725	35166	11081	11441	8567	9800	3640	8645	11458	11107	4452
9	5911	72923	5305	1911	5449	6146	1825	8647	5039	14487	12750
10	2818	19069	1228	1293	4144	1273	1595	7524	4393	2703	4534
11+	10514	19180	4398	3326	7674	11393	4445	21462	11198	10375	9764
sum	479497	951741	509203	516972	424916	476368	282922	468722	562977	512577	773465

age	92/93	93/94	94/95	95/96	96/97
0	2236	5768	2748	1076	1649
1	77347	144386	160711	91792	55670
2	219291	176328	120813	222637	278575
3	264165	168094	110214	155959	167504
4	81798	138381	169471	65050	97089
5	63496	63985	184867	64790	61187
6	40082	23016	78549	51925	26797
7	21096	22691	12400	33821	27437
8	18025	18245	41243	12544	32928
9	4935	12324	27603	5974	8285
10	7395	2150	10471	6225	1939
11+	22231	26181	19732	12035	13363
sum	822096	801551	938822	723827	772422

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch).

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	1361121	1384770	1733198	2186342	2586446	2124006	6679362	7947624	4316374	7661050	3980609
1	1656056	1098335	1116646	1415699	1808059	2152478	1754161	5670480	6766275	3641546	6520236
2	2132555	1418968	925892	933805	1209635	1473084	1732963	1313871	4854020	5718867	2990762
3	1482445	1819522	1194292	720834	788340	916263	1052653	1244415	913502	4043925	4736316
4	1960722	1203519	1504150	829771	586257	641128	640420	744401	877983	643833	3311230
5	1138472	1211793	868676	1190034	540687	405465	377110	444135	465370	654877	444192
6	833077	807278	781818	609025	844987	331833	275433	250609	292312	330338	487162
7	836824	614254	538388	591740	402418	589338	223537	197447	149215	205866	221664
8	313312	583785	372052	335853	358651	189998	418602	156667	108905	97161	150253
9	104394	217647	356857	189562	238943	123977	110709	338804	110825	76989	68331
10	282237	12595	161866	242963	101244	150081	90124	82400	246930	85228	41015
11+	357806	503891	330726	333790	368272	322522	328787	309018	243833	340865	298817

age	92/93	93/94	94/95	95/96	96/97
0	1487789	2947311	3415812	6674751	7141443
1	3353248	1207412	2463113	2867342	5671968
2	5512166	2803569	972104	2027786	2346126
3	2230267	4477888	2300669	689007	1557457
4	3923910	1612049	3713481	1885475	469487
5	2756018	3273166	1262790	3097031	1560164
6	284030	2306032	2774225	964183	2584162
7	329814	190046	1946113	2330971	737083
8	144900	233953	126897	1658316	1978714
9	99719	93518	155612	83832	1408625
10	46720	59117	60155	97385	46777
11+	220897	144386	110825	107216	136684

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.0645	0.0652	0.0523	0.0400	0.0337	0.0413	0.0137	0.0109	0.0200	0.0112	0.0215
1	0.0045	0.0208	0.0288	0.0073	0.0549	0.0668	0.1390	0.0055	0.0182	0.0469	0.0180
2	0.0087	0.0224	0.1003	0.0193	0.1278	0.1860	0.1812	0.2134	0.0326	0.0385	0.1434
3	0.0584	0.0403	0.2142	0.0567	0.0567	0.2082	0.1965	0.1988	0.1998	0.0499	0.0382
4	0.3312	0.1760	0.0842	0.2783	0.2187	0.3807	0.2160	0.3197	0.1432	0.2212	0.0335
5	0.1938	0.2882	0.2051	0.1924	0.3382	0.2367	0.2586	0.2683	0.1927	0.1458	0.2972
6	0.1547	0.2551	0.1286	0.2644	0.2103	0.2451	0.1829	0.3685	0.2006	0.2490	0.2401
7	0.2101	0.3514	0.3219	0.3507	0.6005	0.1921	0.2055	0.4450	0.2790	0.1649	0.2751
8	0.2143	0.3422	0.5243	0.1904	0.9123	0.3901	0.0615	0.1962	0.1968	0.2020	0.2600
9	1.9648	0.1461	0.2344	0.4772	0.3150	0.1689	0.1453	0.1663	0.1126	0.4797	0.2302
10	0.0892	0.2958	0.2392	0.2986	0.2255	0.2128	0.1543	0.3233	0.2145	0.2048	0.2808
11+	0.0892	0.2958	0.2392	0.2986	0.2255	0.2128	0.1543	0.3233	0.2145	0.2048	0.2808

age	92/93	93/94	94/95	95/96	96/97
0	0.0588	0.0295	0.0250	0.0128	0.0120
1	0.0290	0.0668	0.0445	0.0506	0.0071
2	0.0578	0.0477	0.1942	0.1139	0.1335
3	0.1746	0.0372	0.0490	0.2336	0.1454
4	0.0313	0.0942	0.0315	0.0394	0.3478
5	0.0283	0.0154	0.1198	0.0310	0.0707
6	0.2518	0.0197	0.0241	0.1186	0.0223
7	0.1934	0.2539	0.0100	0.0138	0.1066
8	0.2879	0.2578	0.2646	0.0132	0.0230
9	0.3728	0.2912	0.3187	0.4334	0.0235
10	0.4671	0.4577	0.3167	0.2534	0.1732
11+	0.4671	0.4577	0.3167	0.2534	0.3014

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

INDEX RESULTS

Fit results for index = NC Com
Index Fitted to Mid-Year Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	0.8627	0.8627	0.6523	0.2104	0.8283
82/83	0.9199	0.9199	1.0566	-0.1367	-0.5381
83/84	0.5814	0.5814	0.8463	-0.2650	-1.0432
84/85	0.7254	0.7254	0.9796	-0.2542	-1.0008
85/86	0.9258	0.9258	0.8159	0.1099	0.4328
86/87	1.2100	1.2100	1.3262	-0.1162	-0.4575
87/88	1.3804	1.3804	1.5038	-0.1234	-0.4860
88/89	1.0693	1.0693	0.6206	0.4487	1.7664
89/90	0.9892	0.9892	0.7830	0.2062	0.8119
90/91	1.0836	1.0836	0.4840	0.5995	2.3605
91/92	1.1177	1.1177	1.1986	-0.0809	-0.3185
92/93	1.3648	1.3648	1.1351	0.2297	0.9042
93/94	1.1556	1.1556	1.2104	-0.0548	-0.2159
94/95	0.8949	0.8949	0.5950	0.2999	1.1809
95/96	0.7622	0.7622	0.8998	-0.1377	-0.5420
96/97	0.9572	0.9572	1.0955	-0.1383	-0.5446

ML estimate of catchability: 0.80642E-07
Index ML estimate of the variance: 0.0645 (S.E.: 0.2540)
Pearsons (parametric) correlation: 0.514 P= 0.0013
Kendalls (nonparametric) Tau: 0.350 P= 0.0053

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
81/82	0.007	0.031	0.137	0.108	0.451	0.061	0.027	1.000	0.069	0.192
82/83	0.013	0.039	0.135	0.181	0.064	0.538	0.090	0.001	0.193	1.000
83/84	0.024	0.018	0.057	0.112	0.274	0.571	0.112	0.452	1.000	0.135
84/85	0.025	0.051	0.027	0.036	0.571	0.315	0.330	1.000	0.294	0.770
85/86	0.031	0.119	0.065	0.132	0.137	0.667	0.689	0.581	1.000	0.271
86/87	0.234	0.248	0.491	0.335	0.279	0.711	0.301	0.947	1.000	0.772
87/88	0.262	0.551	0.708	0.827	0.697	1.000	0.239	0.904	0.720	0.660
88/89	0.083	0.077	0.108	0.589	0.550	1.000	0.258	0.088	0.345	0.237
89/90	0.048	0.346	0.231	0.496	0.581	1.000	0.211	0.116	0.235	0.231
90/91	0.038	0.033	0.211	0.184	0.270	0.206	0.273	1.000	0.301	0.096
91/92	0.308	0.069	0.065	1.000	0.506	0.550	0.712	0.492	0.192	0.274
92/93	0.103	0.339	0.081	0.052	1.000	0.242	0.196	0.746	0.356	0.427
93/94	0.114	0.137	0.262	0.029	0.060	0.724	0.878	0.719	0.789	1.000
94/95	0.159	0.031	0.028	0.136	0.044	0.019	0.498	1.000	0.337	0.439
95/96	0.130	0.359	0.089	0.072	0.316	0.020	0.066	1.000	0.584	0.404
96/97	0.056	0.229	1.000	0.170	0.065	0.272	0.032	0.116	0.385	0.336

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = FDEP
Index Fitted to Beginning Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	0.9664	0.9664	0.7363	0.2301	0.9474
86/87	1.0285	1.0285	0.6510	0.3775	1.5544
87/88	1.1379	1.1379	1.0753	0.0626	0.2576
88/89	1.3583	1.3583	1.1815	0.1768	0.7279
89/90	1.1854	1.1854	1.0141	0.1713	0.7054
90/91	0.9808	0.9808	0.8516	0.1292	0.5319
91/92	0.8687	0.8687	1.2849	-0.4163	-1.7138
92/93	0.8996	0.8996	1.2708	-0.3712	-1.5283
93/94	0.8990	0.8990	0.8249	0.0741	0.3051
94/95	0.8557	0.8557	0.9224	-0.0667	-0.2746
95/96	0.8539	0.8539	0.5462	0.3076	1.2665
96/97	0.9659	0.9659	1.0908	-0.1249	-0.5141

ML estimate of catchability: 0.42533E-07
Index ML estimate of the variance: 0.0590 (S.E.: 0.2429)
Pearsons (parametric) correlation: 0.262 P= 0.1472
Kendalls (nonparametric) Tau: 0.091 P= 0.3964

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
85/86	0.005	0.094	0.522	0.839	0.361	0.280	1.000	0.185	0.494	0.203
86/87	0.142	0.285	1.000	0.621	0.421	0.282	0.511	0.096	0.239	0.292
87/88	0.632	0.807	0.861	1.000	0.635	0.861	0.226	0.442	0.541	0.562
88/89	0.645	0.644	0.702	0.814	0.583	1.000	0.727	0.632	0.819	0.932
89/90	0.096	0.728	0.566	0.636	0.702	0.673	0.923	0.523	0.989	1.000
90/91	0.075	0.181	0.859	0.316	0.826	0.484	0.512	1.000	0.438	0.527
91/92	0.395	0.185	0.178	0.940	1.000	0.978	0.912	0.621	0.628	0.709
92/93	0.186	0.575	0.196	0.180	0.592	0.450	0.654	0.786	1.000	0.890
93/94	0.236	0.154	0.343	0.057	0.059	0.591	0.575	0.775	1.000	0.680
94/95	0.689	0.297	0.162	0.407	0.077	0.038	0.605	0.608	1.000	0.504
95/96	0.224	0.500	0.085	0.081	0.300	0.014	0.022	1.000	0.437	0.346
96/97	0.832	0.734	1.000	0.221	0.046	0.210	0.032	0.031	0.312	0.420

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = MRFSS
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0028	1.0028	0.1402	0.8627	2.3424
82/83	1.3502	1.3502	1.0512	0.2990	0.8117
83/84	0.8722	0.8722	0.6906	0.1815	0.4929
84/85	1.1059	1.1059	1.0784	0.0276	0.0749
85/86	0.7577	0.7577	0.4478	0.3099	0.8413
86/87	1.0191	1.0191	1.1773	-0.1582	-0.4294
87/88	1.1574	1.1574	1.3595	-0.2020	-0.5486
88/89	0.8103	0.8103	1.0224	-0.2121	-0.5759
89/90	0.7020	0.7020	1.3298	-0.6278	-1.7045
90/91	0.7831	0.7831	0.9399	-0.1568	-0.4256
91/92	1.5500	1.5500	1.3996	0.1503	0.4082
92/93	1.5427	1.5427	0.7917	0.7511	2.0392
93/94	0.7417	0.7417	0.4592	0.2825	0.7671
94/95	0.7572	0.7572	0.7139	0.0433	0.1176
95/96	0.8544	0.8544	0.7965	0.0579	0.1572
96/97	0.9932	0.9932	1.0690	-0.0758	-0.2057

ML estimate of catchability: 0.39533E-06
Index ML estimate of the variance: 0.1356 (S.E.: 0.3683)
Pearsons (parametric) correlation: 0.347 P= 0.0335
Kendalls (nonparametric) Tau: 0.300 P= 0.0155

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
81/82	0.004	0.024	0.056	0.060	0.020	0.092	0.079	1.000	0.056	0.035
82/83	0.093	0.141	0.192	0.529	0.597	1.000	0.855	0.335	0.004	0.619
83/84	0.199	0.312	0.130	0.428	0.198	0.501	1.000	0.133	0.215	0.347
84/85	0.074	0.190	0.728	0.541	0.779	1.000	0.358	0.847	0.994	0.870
85/86	0.196	0.032	0.172	0.288	0.196	0.703	1.000	0.351	0.068	0.209
86/87	0.786	0.823	1.000	0.529	0.557	0.408	0.914	0.269	0.384	0.436
87/88	1.000	0.808	0.793	0.974	0.632	0.511	0.204	0.349	0.424	0.462
88/89	0.587	0.523	1.000	0.527	0.727	0.700	0.361	0.340	0.549	0.711
89/90	0.208	1.000	0.723	0.773	0.792	0.738	0.906	0.546	0.979	0.942
90/91	0.136	0.159	0.522	0.413	0.601	0.402	0.528	1.000	0.515	0.688
91/92	0.590	0.144	0.075	0.797	0.702	0.954	0.831	0.810	0.934	1.000
92/93	0.116	0.328	0.045	0.044	0.380	0.386	0.702	0.779	1.000	0.949
93/94	0.082	0.058	0.157	0.026	0.029	0.441	0.499	0.572	0.780	1.000
94/95	0.572	0.107	0.073	0.340	0.063	0.019	0.699	0.743	0.840	1.000
95/96	0.368	0.717	0.104	0.080	0.263	0.052	0.024	1.000	0.644	0.661
96/97	0.405	0.414	1.000	0.220	0.063	0.313	0.066	0.036	0.558	0.873

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = Headboat
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0468	1.0468	0.5395	0.5073	1.7072
82/83	0.9987	0.9987	0.9555	0.0432	0.1454
83/84	0.9571	0.9571	0.5888	0.3683	1.2396
84/85	1.0713	1.0713	0.9615	0.1098	0.3696
85/86	0.9027	0.9027	0.3385	0.5642	1.8987
86/87	0.8872	0.8872	0.9597	-0.0725	-0.2440
87/88	0.8629	0.8629	1.0006	-0.1377	-0.4633
88/89	0.8932	0.8932	1.2937	-0.4005	-1.3479
89/90	0.9704	0.9704	1.3217	-0.3514	-1.1825
90/91	0.9475	0.9475	0.7245	0.2230	0.7505
91/92	1.2101	1.2101	1.4121	-0.2021	-0.6801
92/93	0.9746	0.9746	1.0024	-0.0278	-0.0934
93/94	0.9295	0.9295	0.4207	0.5088	1.7124
94/95	1.0036	1.0036	0.9272	0.0764	0.2573
95/96	0.9448	0.9448	0.8890	0.0557	0.1875
96/97	1.3997	1.3997	1.2577	0.1420	0.4780

ML estimate of catchability: 0.42754E-06
Index ML estimate of the variance: 0.0883 (S.E.: 0.2971)
Pearsons (parametric) correlation: 0.414 P= 0.0112
Kendalls (nonparametric) Tau: 0.183 P= 0.1140

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
81/82	0.011	0.065	0.282	0.176	0.168	0.210	0.712	1.000	0.005	0.141
82/83	0.095	0.118	0.050	0.475	0.499	0.827	1.000	0.394	0.002	0.325
83/84	0.169	0.337	0.120	0.204	0.253	0.008	1.000	0.167	0.007	0.339
84/85	0.031	0.079	0.866	0.630	0.802	0.494	0.002	0.118	1.000	0.404
85/86	0.086	0.029	0.110	0.210	0.332	0.205	1.000	0.050	0.003	0.042
86/87	0.329	0.761	1.000	0.533	0.523	0.337	0.747	0.157	0.275	0.360
87/88	0.435	0.667	0.665	1.000	0.587	0.366	0.194	0.314	0.355	0.361
88/89	0.732	0.804	0.681	0.385	0.814	1.000	0.578	0.575	0.847	0.905
89/90	0.149	1.000	0.749	0.783	0.793	0.682	0.861	0.536	0.973	0.840
90/91	0.085	0.069	0.441	0.388	0.555	0.378	0.496	1.000	0.511	0.671
91/92	0.555	0.119	0.069	0.886	0.708	1.000	0.880	0.751	0.753	0.753
92/93	0.151	0.401	0.045	0.046	0.485	0.468	0.504	0.618	0.986	1.000
93/94	0.080	0.048	0.123	0.018	0.022	0.345	0.421	0.457	0.672	1.000
94/95	0.875	0.142	0.090	0.329	0.061	0.021	0.636	0.706	0.979	1.000
95/96	0.471	0.729	0.118	0.049	0.277	0.017	0.024	1.000	0.692	0.639
96/97	0.462	0.490	1.000	0.190	0.074	0.358	0.057	0.040	0.701	0.996

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = Res Surv
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	0.1935	0.1935	0.4202	-0.2267	-1.7976
87/88	1.3390	1.3390	1.3393	-0.0003	-0.0024
88/89	1.5953	1.5953	1.5958	-0.0005	-0.0040
89/90	0.8578	0.8578	0.8629	-0.0051	-0.0402
90/91	1.5378	1.5378	1.5381	-0.0003	-0.0021
91/92	0.7951	0.7951	0.7952	-0.0001	-0.0010
92/93	0.6434	0.6434	0.2919	0.3515	2.7869
93/94	0.5858	0.5858	0.5865	-0.0007	-0.0053
94/95	0.6800	0.6800	0.6812	-0.0012	-0.0096
95/96	1.3390	1.3390	1.3390	0.0000	0.0000
96/97	1.4332	1.4332	1.4332	0.0000	0.0000

ML estimate of catchability: 0.21738E-06
Index ML estimate of the variance: 0.0159 (S.E.: 0.1261)
Pearsons (parametric) correlation: 0.961 P= 0.0000
Kendalls (nonparametric) Tau: 0.917 P= 0.0000

Selectivities set to 1.0

year	0
86/87	1.000
87/88	1.000
88/89	1.000
89/90	1.000
90/91	1.000
91/92	1.000
92/93	1.000
93/94	1.000
94/95	1.000
95/96	1.000
96/97	1.000

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

```
   Run name: Atl King low bycatch w/ mixing area fish
   No. index values:  71  Parameters: 12
   Mean Squared Error (rss/df) =  0.93188E-01
   Rsquared = -0.1978
   Loglikelihood = -0.36613E+01

Program termination OK
```

Parameter		Estimate	S.E.	% C.V.
F age	0	0.0120	0.00316	26.25
F age	1	0.0071	0.00190	26.75
F age	2	0.1335	0.04680	35.06
F age	3	0.1454	0.06066	41.73
F age	4	0.3478	0.05085	14.62
F age	5	0.0707	0.02557	36.20
F age	6	0.0223	0.00703	31.55
F age	7	0.1066	0.06488	60.86
F age	8	0.0230	0.00728	31.64
F age	9	0.0235	0.00769	32.70
F age	10	0.1732	0.04245	24.52
F age	11	0.3014	0.09894	32.82

Table 2b. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance high bycatch).

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	1510275	1533903	1882347	2335488	2735382	2273378	6980152	8291805	4536072	7995472	4189368
1	1655994	1098298	1116591	1415588	1807882	2152085	1754186	5800670	6933798	3701978	6679360
2	2132431	1418915	925861	933757	1209540	1472931	1732625	1313893	4966075	5863055	3042775

age	92/93	93/94	94/95	95/96	96/97
0	1635739	3120903	3605265	6975507	7458157
1	3404275	1206310	2483916	2901772	5802126
2	5649125	2847488	971155	2045691	2375759

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.1685	0.1675	0.1350	0.1061	0.0898	0.1093	0.0351	0.0289	0.0532	0.0299	0.0575
1	0.0045	0.0208	0.0288	0.0073	0.0549	0.0668	0.1390	0.0053	0.0177	0.0461	0.0175
2	0.0087	0.0224	0.1004	0.0193	0.1278	0.1861	0.1812	0.2134	0.0318	0.0375	0.1408

age	92/93	93/94	94/95	95/96	96/97
0	0.1545	0.0783	0.0671	0.0342	0.0320
1	0.0286	0.0668	0.0441	0.0500	0.0070
2	0.0564	0.0469	0.1944	0.1128	0.1317

Table 2b. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance high bycatch) (cont.).

```
Run name: Atl King high bycatch w/ mixing area fish
No. index values:  71  Parameters: 12
Mean Squared Error (rss/df) =  0.93120E-01
Rsquared = -0.1969
Loglikelihood = -0.35577E+01

Program termination OK

Parameter    Estimate     S.E.        % C.V.
F age   0    0.0320      0.00828      25.86
F age   1    0.0070      0.00185      26.62
F age   2    0.1317      0.04618      35.06
F age   3    0.1438      0.06059      42.13
F age   4    0.3484      0.05090      14.61
F age   5    0.0694      0.02515      36.26
F age   6    0.0217      0.00676      31.22
F age   7    0.1030      0.06177      59.98
F age   8    0.0223      0.00697      31.22
F age   9    0.0229      0.00740      32.38
F age  10    0.1731      0.04262      24.62
F age  11    0.3019      0.09906      32.81
```

Table 2c. Atlantic king mackerel tuned virtual population analysis results (Harris bycatch).

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	2900336	2923984	3274401	3729310	4129187	3668517	9661483	11346935	6523799	10966544	6084589
1	1655647	1098093	1116282	1414966	1806883	2149873	1754537	6901280	8355613	4207333	8028924
2	2131735	1418616	925684	933491	1209005	1472072	1730721	1314194	5913379	7086818	3477728

age	92/93	93/94	94/95	95/96	96/97
0	3019789	4721567	5338104	9656651	10276506
1	3830418	1200148	2658425	3189039	6902555
2	6810701	3214269	965852	2195888	2623005

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.8213	0.8129	0.6890	0.5746	0.5027	0.5876	0.1864	0.1560	0.2886	0.1618	0.3128
1	0.0045	0.0208	0.0288	0.0073	0.0549	0.0669	0.1390	0.0045	0.0147	0.0404	0.0146
2	0.0088	0.0224	0.1004	0.0193	0.1278	0.1862	0.1814	0.2134	0.0267	0.0310	0.1221

age	92/93	93/94	94/95	95/96	96/97
0	0.7727	0.4244	0.3652	0.1858	0.1736
1	0.0254	0.0672	0.0411	0.0454	0.0058
2	0.0465	0.0415	0.1956	0.1047	0.1186

Table 2c. Atlantic king mackerel tuned virtual population analysis results (Harris bycatch) (cont.)

```
Run name: Atl King Harris bycatch w/ mixing area fish
No. index values:  71  Parameters: 12
Mean Squared Error (rss/df) =  0.92732E-01
Rsquared = -0.1919
Loglikelihood = -0.29433E+01

Program termination OK

Parameter     Estimate      S.E.        % C.V.
F age   0     0.1736      0.04145       23.88
F age   1     0.0058      0.00155       26.52
F age   2     0.1186      0.04449       37.53
F age   3     0.1322      0.06072       45.94
F age   4     0.3520      0.05144       14.61
F age   5     0.0602      0.02254       37.44
F age   6     0.0174      0.00520       29.82
F age   7     0.0802      0.04455       55.51
F age   8     0.0179      0.00532       29.70
F age   9     0.0186      0.00579       31.19
F age  10     0.1728      0.04219       24.42
F age  11     0.3046      0.10033       32.94
```

Table 3a. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Atlantic king mackerel using Vaughan and Nance low bycatch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
5	4.50	2.29	0.95	0.34	0.21	0.17	0.14	0.11	0.08
6	13.28	4.76	2.17	0.95	0.30	0.21	0.17	0.13	0.10
7	27.15	11.83	4.24	1.81	0.87	0.24	0.19	0.15	0.11
8	40.69	20.99	8.88	3.67	1.35	0.48	0.22	0.17	0.13
9	52.94	33.18	15.19	5.35	2.68	0.93	0.25	0.19	0.15
10	63.50	43.98	24.17	10.67	3.75	1.42	0.47	0.21	0.16
11	70.41	53.93	34.66	15.75	5.52	2.56	0.85	0.24	0.18
12	76.26	62.18	42.76	21.71	9.34	3.42	1.08	0.31	0.19
13	78.26	68.44	51.53	30.34	12.59	4.83	1.89	0.49	0.21
14	79.94	74.30	58.30	37.53	18.51	6.86	2.83	0.81	0.23
15	82.67	76.62	63.59	44.44	22.96	9.18	3.35	0.98	0.24
16	85.71	78.45	69.29	51.68	29.44	12.30	4.55	1.52	0.32
17	86.70	79.82	73.85	57.20	34.97	15.44	5.37	2.00	0.44
18	87.89	81.84	75.92	62.31	40.49	19.49	7.15	2.81	0.64
19	89.19	83.91	77.10	64.89	45.85	22.79	8.37	3.32	0.89
20	90.47	86.03	78.48	69.87	51.70	26.80	11.50	3.90	1.12
21	91.38	86.80	79.96	72.55	55.28	31.69	13.18	4.46	1.35
22	92.33	88.02	81.27	75.25	58.68	36.66	15.70	5.41	1.72
23	93.37	89.04	83.04	76.18	62.40	40.81	18.46	7.07	2.16
24	94.41	90.34	84.76	77.23	65.37	44.51	21.23	7.61	2.90
25	95.29	90.99	86.04	78.14	69.25	48.49	24.38	8.76	3.22

Table 3b. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Atlantic king mackerel using Vaughan and Nance high bycatch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
5	5.47	2.55	0.62	0.31	0.21	0.18	0.14	0.11	0.08
6	11.94	5.49	2.77	0.62	0.30	0.21	0.17	0.13	0.10
7	23.84	10.77	4.31	1.65	0.57	0.25	0.20	0.16	0.12
8	38.10	20.48	8.50	3.49	0.92	0.46	0.23	0.18	0.13
9	51.25	30.29	13.15	6.46	2.91	0.64	0.28	0.20	0.15
10	61.21	42.33	21.75	9.47	3.48	1.31	0.45	0.22	0.17
11	67.54	53.03	30.86	14.00	6.58	2.82	0.63	0.24	0.18
12	71.43	60.47	39.88	20.56	9.04	3.47	0.94	0.34	0.20
13	75.38	64.97	48.92	28.44	11.35	5.13	1.49	0.46	0.22
14	79.71	70.62	55.63	35.58	15.73	6.49	3.01	0.65	0.23
15	82.61	72.87	62.37	41.97	21.76	8.73	3.53	0.88	0.25
16	85.32	76.37	64.89	49.29	27.30	11.25	4.42	1.18	0.34
17	87.29	79.57	69.46	53.61	32.94	13.78	5.62	1.51	0.43
18	88.31	82.02	71.94	60.19	38.29	17.22	6.65	2.67	0.56
19	89.07	83.80	74.66	63.51	43.43	21.99	8.06	3.40	0.77
20	90.69	85.46	77.18	64.52	47.72	26.32	10.85	4.03	0.92
21	91.50	87.34	78.71	68.61	51.68	30.42	12.31	4.74	1.09
22	91.88	88.23	81.16	70.96	54.74	35.02	14.06	5.59	1.28
23	93.21	88.82	82.39	72.93	60.70	37.50	16.77	6.16	1.81
24	94.56	89.97	84.54	75.23	62.66	42.70	20.48	7.14	2.66
25	94.81	91.04	85.75	77.28	64.13	45.15	23.00	8.43	3.29

Table 3c. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Atlantic king mackerel using Harris bycatch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
5	2.28	1.03	0.22	0.18	0.15	0.12	0.10	0.08	0.06
6	5.63	2.34	1.02	0.22	0.18	0.15	0.12	0.09	0.07
7	10.59	4.87	1.83	0.77	0.21	0.17	0.14	0.11	0.08
8	20.59	9.09	3.47	1.39	0.24	0.20	0.16	0.12	0.09
9	29.81	15.04	6.56	2.60	1.04	0.22	0.18	0.14	0.10
10	38.79	22.73	10.25	4.32	1.54	0.24	0.20	0.15	0.11
11	49.18	31.21	16.37	6.65	2.59	0.95	0.22	0.17	0.13
12	58.39	37.96	21.70	9.84	3.82	1.31	0.23	0.18	0.14
13	63.74	46.65	29.58	13.49	5.75	2.06	0.76	0.20	0.15
14	68.14	54.17	34.49	19.12	8.02	2.89	0.94	0.21	0.16
15	72.02	60.88	41.14	23.18	10.77	3.71	1.20	0.23	0.17
16	76.20	64.26	46.84	28.87	13.61	5.33	1.67	0.24	0.18
17	78.60	67.70	53.57	33.07	17.19	6.71	2.57	0.77	0.19
18	81.09	70.94	58.46	38.50	20.99	8.87	2.99	0.90	0.21
19	82.98	74.95	63.36	44.10	24.57	10.70	3.78	1.06	0.22
20	85.18	77.47	65.51	47.27	28.51	13.61	4.77	1.50	0.23
21	86.81	79.26	67.51	51.28	31.18	15.69	5.91	1.78	0.24
22	87.56	81.46	70.74	57.26	36.41	17.96	7.12	2.54	0.32
23	88.42	82.50	74.26	61.23	39.69	21.04	8.55	2.86	0.79
24	89.29	84.39	76.26	63.17	44.37	24.14	10.39	3.17	0.88
25	90.13	85.74	78.27	64.51	45.89	26.66	12.47	3.84	0.97

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results.

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	2101863	1483316	910512	1952190	1893027	1798354	3011539	2525502	4294529	3142749	3498872
1	1487943	1385989	874446	439161	1130351	1151235	1131884	1694285	1484867	2335056	1778039
2	971752	1217881	1128385	715765	358412	918807	882352	880877	1360020	1056713	1859069
3	752555	791693	853087	826995	582539	263525	601070	621085	626097	979918	719738
4	777712	577226	567287	568169	527204	455053	165485	452494	449558	439321	694868
5	380247	447474	278970	353598	284848	298385	296437	114923	268020	312268	313852
6	299260	193008	210327	194286	227621	139626	224012	224052	67139	191625	220927
7	161039	210233	77006	123520	122080	128289	87943	170982	137653	45065	132639
8	158638	114462	120027	45546	86642	85340	89560	66797	116800	95706	26116
9	119906	119305	62162	88277	27010	63213	61038	70040	46899	85297	68347
10	27213	92836	32958	46110	70549	17213	46213	48325	49552	33856	56793
11+	101520	93378	118055	118561	130651	154065	128806	137840	126317	129929	122299

age	92/93	93/94	94/95	95/96	96/97
0	3320311	4526405	4108029	5108994	2603516
1	1874150	2188978	2752403	2472061	3188235
2	1272072	1464609	1661919	2108463	1941091
3	1290284	844083	1040214	1251682	1525562
4	474539	818775	539854	752301	884253
5	484430	314887	545779	289972	557268
6	232930	339408	200250	281127	179156
7	161886	154626	257120	93649	183438
8	99826	113533	106160	199321	46374
9	17374	65507	76525	49999	151872
10	44484	9794	42543	37925	35552
11+	133733	119240	80169	73326	74645

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.2164	0.3284	0.5291	0.3464	0.2973	0.2630	0.3752	0.3311	0.4093	0.3696	0.4243
1	0.0003	0.0056	0.0002	0.0032	0.0072	0.0660	0.0507	0.0198	0.1402	0.0280	0.1349
2	0.0049	0.1560	0.1107	0.0060	0.1075	0.2244	0.1511	0.1414	0.1278	0.1840	0.1652
3	0.0652	0.1333	0.2064	0.2502	0.0470	0.2653	0.0839	0.1232	0.1543	0.1437	0.2165
4	0.3527	0.5271	0.2727	0.4905	0.3692	0.2286	0.1646	0.3237	0.1644	0.1363	0.1607
5	0.4781	0.5550	0.1618	0.2405	0.5130	0.0867	0.0800	0.3375	0.1355	0.1460	0.0982
6	0.1531	0.7188	0.3323	0.2647	0.3734	0.2623	0.0701	0.2871	0.1987	0.1679	0.1109
7	0.1414	0.3605	0.3252	0.1546	0.1580	0.1594	0.0750	0.1811	0.1635	0.3455	0.0842
8	0.0849	0.4105	0.1072	0.3225	0.1153	0.1352	0.0458	0.1536	0.1143	0.1367	0.2076
9	0.0559	1.0865	0.0987	0.0242	0.2506	0.1132	0.0335	0.1461	0.1259	0.2067	0.2295
10	0.1211	0.2557	0.0419	0.0314	0.0669	0.0850	0.0388	0.1878	0.1027	0.0921	0.0921
11+	0.1211	0.2557	0.0419	0.0314	0.0669	0.0850	0.0388	0.1878	0.1027	0.0921	0.0921

age	92/93	93/94	94/95	95/96	96/97
0	0.2166	0.2975	0.3079	0.2715	0.3023
1	0.0466	0.0755	0.0665	0.0418	0.0194
2	0.2102	0.1422	0.0835	0.1236	0.1718
3	0.2548	0.2470	0.1240	0.1475	0.1288
4	0.2101	0.2056	0.4215	0.1001	0.1288
5	0.1558	0.2526	0.4634	0.2815	0.1288
6	0.2097	0.0777	0.5600	0.2269	0.1798
7	0.1548	0.1761	0.0546	0.5028	0.1798
8	0.2213	0.1945	0.5529	0.0719	1.4502
9	0.3732	0.2317	0.5020	0.1410	0.0620
10	0.2019	0.2759	0.3149	0.1991	0.0620
11+	0.2019	0.2759	0.3149	0.1991	0.2191

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.). INDEX

RESULTS

Fit results for index = FDEP NW

Index Fitted to Beginning Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	0.5318	0.5318	0.7866	-0.2548	-1.7056
86/87	0.7917	0.7917	0.9049	-0.1132	-0.7577
87/88	0.7203	0.7203	0.3875	0.3328	2.2280
88/89	0.5593	0.5593	0.6539	-0.0946	-0.6333
89/90	0.6945	0.6945	0.6896	0.0049	0.0329
90/91	0.8529	0.8529	0.8192	0.0338	0.2262
91/92	1.1802	1.1802	1.0804	0.0998	0.6679
92/93	1.1410	1.1410	1.2801	-0.1391	-0.9312
93/94	1.1314	1.1314	1.2167	-0.0854	-0.5715
94/95	1.3186	1.3186	1.2651	0.0536	0.3586
95/96	1.0779	1.0779	1.0816	-0.0037	-0.0248
96/97	2.0004	2.0004	1.8282	0.1723	1.1535

ML estimate of catchability: 0.94959E-07

Index ML estimate of the variance: 0.0223 (S.E.: 0.1494)

Pearsons (parametric) correlation: 0.924 P= 0.0000

Kendalls (nonparametric) Tau: 0.697 P= 0.0000

Selectivity at age from Partial Catches

year	3	4	5	6
85/86	0.037	1.000	0.702	0.314
86/87	0.797	1.000	0.940	0.361
87/88	0.270	1.000	0.355	0.083
88/89	0.298	1.000	0.191	0.399
89/90	1.000	0.508	0.248	0.224
90/91	0.749	0.150	0.116	1.000
91/92	0.648	1.000	0.346	0.208
92/93	1.000	0.201	0.507	0.342
93/94	1.000	0.565	0.562	0.186
94/95	0.328	1.000	0.624	0.766
95/96	0.241	0.461	0.670	1.000
96/97	1.000	0.836	0.184	0.437

Fit results for index = FDEP SW

Index Fitted to Mid-Year Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	0.4595	0.4595	0.3600	0.0996	0.3243
86/87	0.4548	0.4548	0.6956	-0.2408	-0.7844
87/88	0.6192	0.6192	0.5278	0.0914	0.2977
88/89	0.8817	0.8817	0.4913	0.3903	1.2713
89/90	0.8268	0.8268	1.1360	-0.3092	-1.0070
90/91	1.0753	1.0753	1.1270	-0.0517	-0.1683
91/92	1.0553	1.0553	1.1491	-0.0938	-0.3054
92/93	2.0982	2.0982	1.2889	0.8093	2.6358
93/94	1.2998	1.2998	1.4848	-0.1850	-0.6026
94/95	0.7294	0.7294	1.0552	-0.3258	-1.0611
95/96	1.1178	1.1178	1.1130	0.0048	0.0156
96/97	1.3822	1.3822	1.3974	-0.0151	-0.0493

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.). ML

estimate of catchability: 0.11357E-06
Index ML estimate of the variance: 0.0943 (S.E.: 0.3070)
Pearsons (parametric) correlation: 0.722 P= 0.0000
Kendalls (nonparametric) Tau: 0.576 P= 0.0002

Selectivity at age from Partial Catches

year	3	4	5	6	7	8
85/86	0.002	0.000	1.000	0.311	0.005	0.026
86/87	0.500	1.000	0.603	0.100	0.024	0.018
87/88	0.314	1.000	0.150	0.664	0.000	0.000
88/89	0.013	1.000	0.949	0.007	0.002	0.059
89/90	0.689	1.000	0.616	0.476	0.901	0.234
90/91	0.902	1.000	0.021	0.468	0.684	0.000
91/92	0.619	1.000	0.115	0.422	0.382	0.354
92/93	1.000	0.026	0.747	0.074	0.003	0.386
93/94	1.000	0.640	0.644	0.186	0.636	0.332
94/95	0.423	1.000	0.371	0.330	0.023	0.476
95/96	0.626	0.254	1.000	0.091	0.237	0.199
96/97	1.000	0.260	0.121	0.329	0.067	0.693

Fit results for index = MRFSS
Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	0.2148	0.2148	0.8491	-0.6343	-1.2224
87/88	0.8052	0.8052	0.7095	0.0957	0.1845
88/89	0.4756	0.4756	0.9209	-0.4453	-0.8583
89/90	0.8034	0.8034	0.9179	-0.1145	-0.2206
90/91	1.8332	1.8332	0.5513	1.2819	2.4707
91/92	2.2057	2.2057	1.5504	0.6553	1.2630
92/93	1.3793	1.3793	1.4975	-0.1182	-0.2278
93/94	0.7956	0.7956	1.2658	-0.4702	-0.9063
94/95	1.0140	1.0140	1.0353	-0.0213	-0.0410
95/96	0.4614	0.4614	0.2877	0.1736	0.3346
96/97	1.0119	1.0119	1.0046	0.0073	0.0141

ML estimate of catchability: 0.50866E-06
Index ML estimate of the variance: 0.2692 (S.E.: 0.5189)
Pearsons (parametric) correlation: 0.458 P= 0.0189
Kendalls (nonparametric) Tau: 0.382 P= 0.0147

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
86/87	0.991	1.000	0.709	0.267	0.434	0.194	0.081
87/88	1.000	0.454	0.524	0.326	0.160	0.126	0.102
88/89	0.705	0.518	0.993	0.456	1.000	0.601	0.577
89/90	0.544	0.749	0.722	0.328	0.291	1.000	0.224
90/91	0.418	0.409	0.189	0.167	0.238	1.000	0.152
91/92	1.000	0.706	0.813	0.234	0.127	0.079	0.130
92/93	0.927	1.000	0.142	0.403	0.587	0.077	0.623
93/94	0.582	1.000	0.546	0.514	0.157	0.551	0.388
94/95	0.378	0.398	1.000	0.472	0.495	0.055	0.773
95/96	0.052	0.111	0.043	0.574	0.063	1.000	0.037
96/97	0.404	0.285	0.256	0.413	0.631	0.758	1.000

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = TPWD

	Index Fitted to Beginning Stock Size in NUMBERS				
	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0808	1.0808	0.7659	0.3149	0.6577
82/83	0.9143	0.9143	0.7385	0.1759	0.3673
83/84	1.1792	1.1792	0.3160	0.8632	1.8032
84/85	1.1177	1.1177	0.6041	0.5136	1.0729
85/86	1.0266	1.0266	0.3798	0.6468	1.3511
86/87	0.7471	0.7471	0.8777	-0.1305	-0.2727
87/88	0.9084	0.9084	0.4852	0.4232	0.8839
88/89	0.7760	0.7760	0.5261	0.2499	0.5221
89/90	0.9094	0.9094	0.4621	0.4473	0.9344
90/91	0.8760	0.8760	0.4826	0.3934	0.8218
91/92	1.1393	1.1393	0.5979	0.5414	1.1309
92/93	1.0356	1.0356	1.4004	-0.3648	-0.7620
93/94	1.0965	1.0965	1.4633	-0.3668	-0.7661
94/95	0.9890	0.9890	1.6461	-0.6571	-1.3726
95/96	1.1190	1.1190	1.3358	-0.2167	-0.4527
96/97	1.0848	1.0848	0.4091	0.6757	1.4115

ML estimate of catchability: 0.74526E-06
Index ML estimate of the variance: 0.2292 (S.E.: 0.4787)
Pearsons (parametric) correlation: 0.118 P= 0.3662
Kendalls (nonparametric) Tau: -0.050 P= 0.4967

	Selectivity at age from Partial Catches						
year	2	3	4	5	6	7	8
81/82	0.002	0.065	0.461	1.000	0.528	0.488	0.013
82/83	0.021	0.009	0.497	1.000	0.290	0.577	0.400
83/84	0.004	0.018	0.190	0.285	0.648	1.000	0.029
84/85	0.001	0.087	0.398	0.999	0.244	0.537	1.000
85/86	0.028	0.021	0.213	0.680	0.245	1.000	0.040
86/87	0.127	0.835	0.677	0.694	0.958	1.000	0.748
87/88	0.142	0.315	1.000	0.227	0.228	0.257	0.332
88/89	0.106	0.252	0.409	1.000	0.378	0.302	0.292
89/90	0.056	0.220	0.303	0.450	1.000	0.375	0.269
90/91	0.099	0.108	0.313	0.432	0.444	1.000	0.361
91/92	0.090	0.399	0.188	0.269	0.296	0.312	1.000
92/93	0.226	0.496	0.687	0.480	0.739	0.743	1.000
93/94	0.321	0.496	0.636	0.885	0.189	1.000	0.490
94/95	0.335	0.737	0.394	0.688	1.000	0.282	0.231
95/96	0.278	0.336	0.372	0.690	0.652	1.000	0.144
96/97	0.087	0.088	0.090	0.092	0.236	0.147	1.000

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = Headboat
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0758	1.0758	0.5239	0.5519	1.7300
82/83	0.7533	0.7533	0.5362	0.2171	0.6804
83/84	1.2663	1.2663	0.8573	0.4090	1.2820
84/85	0.6375	0.6375	0.4971	0.1404	0.4402
85/86	0.7560	0.7560	0.4056	0.3505	1.0987
86/87	0.9245	0.9245	0.3740	0.5506	1.7259
87/88	0.7519	0.7519	0.6060	0.1459	0.4574
88/89	0.4943	0.4943	0.4014	0.0929	0.2911
89/90	1.1189	1.1189	1.3488	-0.2299	-0.7206
90/91	1.2202	1.2202	1.1264	0.0938	0.2939
91/92	1.0760	1.0760	1.1062	-0.0302	-0.0946
92/93	1.1366	1.1366	1.4124	-0.2758	-0.8645
93/94	1.0107	1.0107	1.2557	-0.2450	-0.7680
94/95	1.1293	1.1293	0.5512	0.5781	1.8123
95/96	1.0033	1.0033	1.2437	-0.2404	-0.7537
96/97	1.6451	1.6451	1.8526	-0.2074	-0.6502

ML estimate of catchability: 0.71972E-06
Index ML estimate of the variance: 0.1018 (S.E.: 0.3190)
Pearsons (parametric) correlation: 0.756 P= 0.0000
Kendalls (nonparametric) Tau: 0.500 P= 0.0001

Selectivity at age from Partial Catches

year	2	3	4	5	6
81/82	0.035	0.120	1.000	0.001	0.080
82/83	0.020	0.415	1.000	0.007	0.259
83/84	0.001	1.000	0.646	0.756	0.124
84/85	0.008	0.095	1.000	0.459	0.515
85/86	1.000	0.016	0.375	0.445	0.029
86/87	0.116	0.661	0.476	0.021	1.000
87/88	0.413	0.431	1.000	0.373	0.378
88/89	0.156	0.142	1.000	0.156	0.000
89/90	1.000	0.831	0.490	0.280	0.502
90/91	0.371	1.000	0.924	0.006	0.398
91/92	0.250	1.000	0.864	0.068	0.194
92/93	0.424	0.714	1.000	0.635	0.685
93/94	0.378	0.646	0.721	1.000	0.328
94/95	0.048	0.080	0.260	0.955	1.000
95/96	0.353	0.456	0.285	1.000	0.848
96/97	0.605	0.504	0.476	1.000	0.699

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = Chart NWF

Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	0.9278	0.9278	0.6454	0.2824	1.3183
89/90	0.9164	0.9164	1.0402	-0.1238	-0.5777
90/91	0.9148	0.9148	0.8323	0.0825	0.3850
91/92	0.9883	0.9883	1.2929	-0.3046	-1.4216
92/93	1.0380	1.0380	0.9800	0.0580	0.2705
93/94	0.9670	0.9670	1.0557	-0.0887	-0.4142
94/95	1.2478	1.2478	0.9081	0.3397	1.5857

ML estimate of catchability: 0.43112E-06
Index ML estimate of the variance: 0.0459 (S.E.: 0.2142)
Pearsons (parametric) correlation: 0.054 P= 0.6020
Kendalls (nonparametric) Tau: 0.143 P= 0.3705

Selectivity at age from Partial Catches

year	2	3	4	5	6
88/89	0.568	0.482	1.000	0.492	0.843
89/90	0.901	1.000	0.886	0.464	0.569
90/91	1.000	0.578	0.358	0.291	0.308
91/92	1.000	0.704	0.764	0.230	0.136
92/93	1.000	0.575	0.307	0.129	0.218
93/94	0.653	1.000	0.542	0.466	0.167
94/95	0.449	0.413	1.000	0.501	0.586

Fit results for index = Chart SWF

Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	0.7913	0.7913	0.8342	-0.0429	-0.1093
89/90	1.0462	1.0462	0.9927	0.0535	0.1365
90/91	0.8940	0.8940	0.2942	0.5999	1.5293
91/92	0.7323	0.7323	0.7053	0.0270	0.0689
92/93	0.9435	0.9435	1.1257	-0.1822	-0.4645
93/94	1.0652	1.0652	1.4668	-0.4016	-1.0239
94/95	1.5274	1.5274	0.8082	0.7192	1.8336

ML estimate of catchability: 0.10697E-05
Index ML estimate of the variance: 0.1539 (S.E.: 0.3923)
Pearsons (parametric) correlation: 0.192 P= 0.3547
Kendalls (nonparametric) Tau: 0.333 P= 0.0969

Selectivity at age from Partial Catches

year	3	4	5	6	7	8
88/89	0.407	0.790	1.000	0.519	0.516	0.552
89/90	1.000	0.608	0.295	0.453	0.373	0.364
90/91	0.112	0.156	0.169	0.259	1.000	0.032
91/92	0.579	0.229	0.152	0.488	0.259	1.000
92/93	0.478	0.456	0.358	0.391	0.565	1.000
93/94	0.615	0.717	1.000	0.338	0.278	0.861
94/95	0.074	0.247	0.917	1.000	0.066	0.923

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = Bycatch Index

Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	0.6148	0.6148	0.7221	-0.1072	-0.6529
82/83	0.5980	0.5980	0.5096	0.0884	0.5383
83/84	0.5450	0.5450	0.3128	0.2322	1.4139
84/85	0.7723	0.7723	0.6706	0.1017	0.6191
85/86	0.6508	0.6508	0.6503	0.0005	0.0030
86/87	0.4723	0.4723	0.6178	-0.1455	-0.8860
87/88	0.9661	0.9661	1.0346	-0.0685	-0.4169
88/89	0.8357	0.8357	0.8676	-0.0319	-0.1941
89/90	1.7011	1.7011	1.4753	0.2258	1.3747
90/91	1.2110	1.2110	1.0796	0.1314	0.7998
91/92	1.4128	1.4128	1.2020	0.2108	1.2833
92/93	0.6929	0.6929	1.1406	-0.4478	-2.7261
93/94	1.4655	1.4655	1.5550	-0.0895	-0.5451
94/95	1.4122	1.4122	1.4113	0.0009	0.0055
95/96	1.7551	1.7551	1.7551	0.0000	0.0000
96/97	0.8944	0.8944	0.8944	0.0000	0.0000

ML estimate of catchability: 0.34354E-06

Index ML estimate of the variance: 0.0270 (S.E.: 0.1643)

Pearsons (parametric) correlation: 0.920 P= 0.0000

Kendalls (nonparametric) Tau: 0.817 P= 0.0000

Selectivities set to 1.0

year	0
81/82	1.000
82/83	1.000
83/84	1.000
84/85	1.000
85/86	1.000
86/87	1.000
87/88	1.000
88/89	1.000
89/90	1.000
90/91	1.000
91/92	1.000
92/93	1.000
93/94	1.000
94/95	1.000
95/96	1.000
96/97	1.000

Fit results for index = SEAMAP

Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	0.5928	0.5928	0.9100	-0.3172	-1.1438
87/88	0.6676	0.6676	0.8946	-0.2270	-0.8185
88/89	0.5928	0.5928	0.9629	-0.3701	-1.3345
89/90	1.1165	1.1165	0.9380	0.1785	0.6436
90/91	0.9381	0.9381	1.0004	-0.0622	-0.2244
91/92	0.9554	0.9554	1.0850	-0.1296	-0.4674
92/93	1.5137	1.5137	1.1886	0.3251	1.1722
93/94	1.6230	1.6230	1.2131	0.4099	1.4779

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

```
    ML estimate of catchability:  0.40661E-06
    Index ML estimate of the variance:     0.0769  (S.E.:     0.2774)
    Pearsons (parametric) correlation:  0.881 P= 0.0000
    Kendalls (nonparametric) Tau:       0.618 P= 0.0017

        Selectivities input
 year    1     2     3     4     5     6     7     8     9    10    11
86/87 0.015 0.121 0.308 0.612 1.037 1.425 1.829 2.247 2.667 3.079 3.853
87/88 0.015 0.121 0.308 0.612 1.037 1.425 1.829 2.247 2.667 3.079 3.853
88/89 0.015 0.121 0.308 0.612 1.037 1.425 1.829 2.247 2.667 3.079 3.853
89/90 0.015 0.121 0.308 0.612 1.037 1.425 1.829 2.247 2.667 3.079 3.853
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92/93 0.015 0.121 0.308 0.612 1.037 1.425 1.829 2.247 2.667 3.079 3.853
93/94 0.015 0.121 0.308 0.612 1.037 1.425 1.829 2.247 2.667 3.079 3.853


    Run name: Gulf King Mackerel without mixing area fish
    No. index values: 105  Parameters:  8
    Mean Squared Error (rss/df) =  0.12475E+00
    Rsquared =  0.1065
    Loglikelihood = -0.18222E+02

 Program termination OK

 Parameter    Estimate     S.E.        % C.V.
 F age   0    0.3023      0.06827      22.59
 F age   1    0.0194      0.00292      15.00
 F age   2    0.1718      0.03523      20.50
 F age   3    0.1288      0.01597      12.39
 F age   6    0.1798      0.03359      18.68
 F age   8    1.4502      0.64564      44.52
 F age   9    0.0620      0.01490      24.03
 F age  11    0.2191      0.11176      51.00
```

Table 5a. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Gulf king mackerel using updated low 1997 catch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
2	4.66	1.94	0.42	0.23	0.18	0.14	0.11	0.08	0.06
3	30.96	16.31	7.80	2.38	0.38	0.21	0.17	0.12	0.09
4	71.13	51.55	30.00	14.24	5.16	0.49	0.22	0.17	0.13
5	92.84	80.33	62.93	42.16	21.95	8.27	0.49	0.21	0.16
6	97.67	93.99	84.76	66.90	46.39	22.97	7.45	0.25	0.19
7	99.31	98.07	94.43	86.77	67.86	45.62	19.38	2.17	0.22
8	99.81	99.25	98.01	94.35	85.87	65.91	37.42	13.16	0.32

Table 5b. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Gulf king mackerel using high 1997 catch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
2	4.99	2.03	0.44	0.23	0.18	0.15	0.11	0.08	0.06
3	32.57	18.15	8.08	2.50	0.41	0.22	0.17	0.13	0.10
4	73.19	52.23	30.47	15.90	5.87	0.64	0.22	0.17	0.13
5	93.30	81.94	64.64	42.84	22.83	9.28	0.66	0.21	0.16
6	97.93	94.37	86.25	69.10	48.29	24.94	8.47	0.33	0.19
7	99.36	98.18	94.78	86.93	69.37	48.04	21.05	3.26	0.22
8	99.81	99.30	98.11	94.47	86.78	66.56	40.56	14.92	0.63

Table 6. Deterministic allowable biological catch (millions of pounds) in the 1998/99 fishing season for the four migratory groups and a range of choices for spawning potential ratio (SPR).

		% Spawning Potential Ratio				
		50	40	30	20	10
Atlantic King Without Mixing Area Fish	low bycatch	5.67	8.41	13.18	22.29	39.42
	high bycatch	7.29	10.89	17.38	30.20	54.35
	Harris bycatch	8.93	13.45	21.79	38.49	69.54
Atlantic King Including Mixing Area Fish	low bycatch	7.65	11.32	17.79	30.67	55.31
	high bycatch	7.86	11.63	18.32	31.68	57.14
	Harris bycatch	9.58	14.30	22.87	40.33	72.97
Gulf King Without Mixing Area Fish	low 97 catch	3.04	4.08	5.48	7.59	11.64
	high 97 catch	3.00	4.03	5.41	7.50	11.50
	updated low 97	3.03	4.06	5.46	7.56	11.60
	updated high 97	2.99	4.01	5.39	7.47	11.46
Gulf King Including Mixing Area Fish	low 97 catch	3.57	4.88	6.72	9.68	15.96
	high 97 catch	3.54	4.83	6.66	9.60	15.82
	updated low 97	3.56	4.86	6.70	9.66	15.92
	updated high 97	3.53	4.82	6.64	9.58	15.78

Table 7. Stochastic simulation median allowable biological catch (millions of pounds) in the 1998/99 fishing season for the four migratory groups and a range of choices for spawning potential ratio (SPR).

		% Spawning Potential Ratio				
		50	40	30	20	10
Atlantic King Without Mixing Area Fish	low bycatch	7.11	10.60	16.14	26.47	46.55
	high bycatch	8.52	12.69	19.93	32.80	58.97
	Harris bycatch	10.38	15.42	24.54	42.10	74.50
Atlantic King Including Mixing Area Fish	low bycatch	8.73	12.69	19.77	33.76	60.53
	high bycatch	8.89	13.06	20.41	35.57	63.87
	Harris bycatch	11.03	16.60	26.66	46.38	83.30
Gulf King Without Mixing Area Fish	low 97 catch	3.43	4.61	6.19	8.53	13.08
	high 97 catch	3.40	4.55	6.10	8.45	12.93
	updated low 97	3.42	4.59	6.17	8.51	13.03
	updated high 97	3.39	4.53	6.07	8.42	12.89
Gulf King Including Mixing Area Fish	low 97 catch	3.83	5.24	7.23	10.54	17.39
	high 97 catch	3.80	5.20	7.17	10.46	17.24
	updated low 97	3.82	5.23	7.21	10.52	17.35
	updated high 97	3.79	5.18	7.15	10.43	17.20

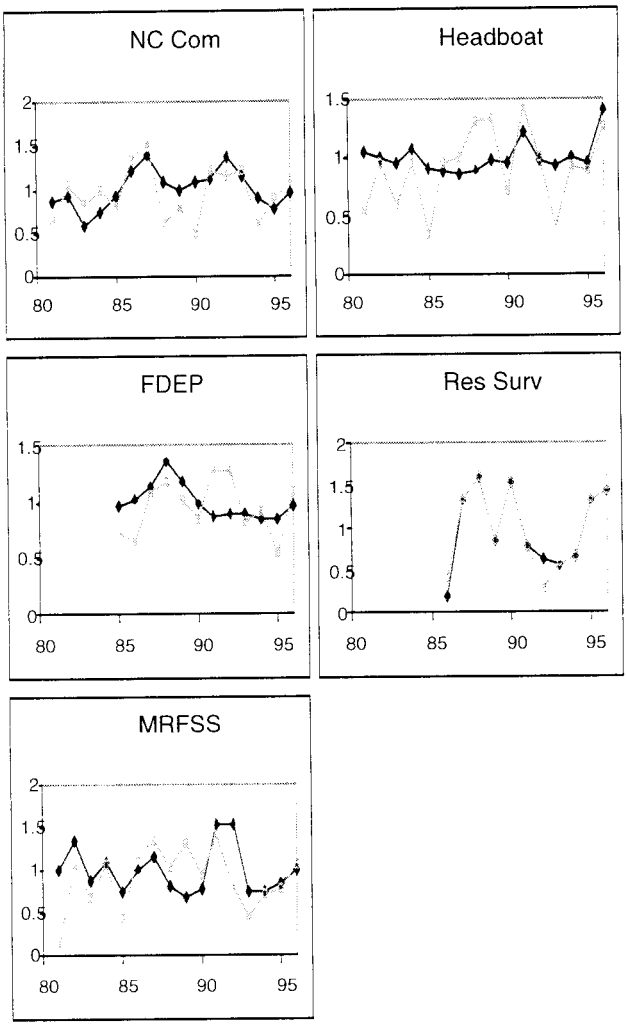

Figure 1a. Comparison of observed (filled diamonds) and predicted (open squares) indices for Atlantic king mackerel using Vaughan and Nance low bycatch.

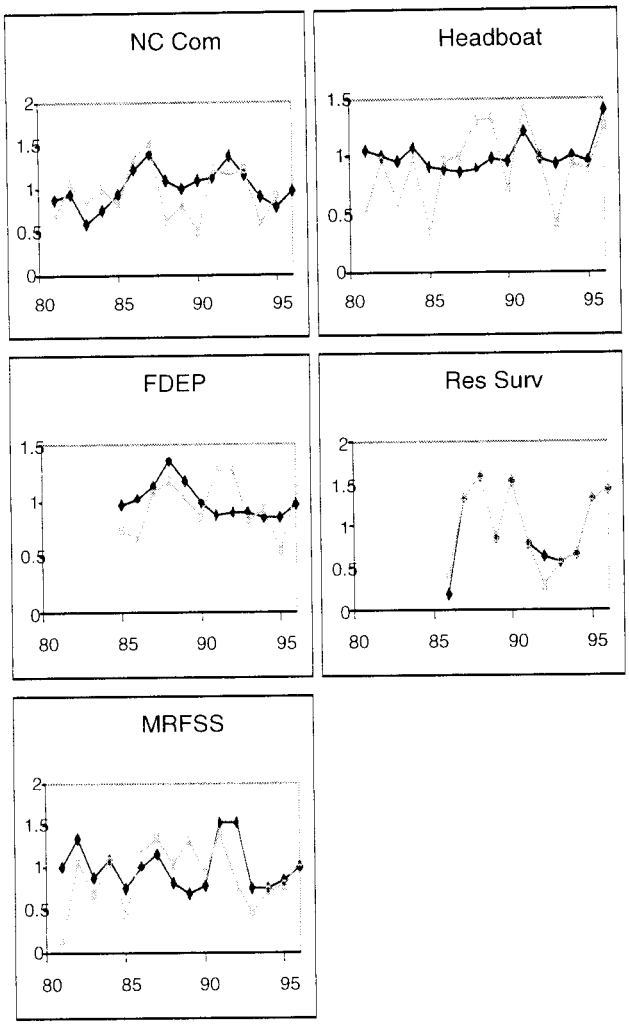

Figure 1b. Comparison of observed (filled diamonds) and predicted (open squares) indices for Atlantic king mackerel using Vaughan and Nance high bycatch.

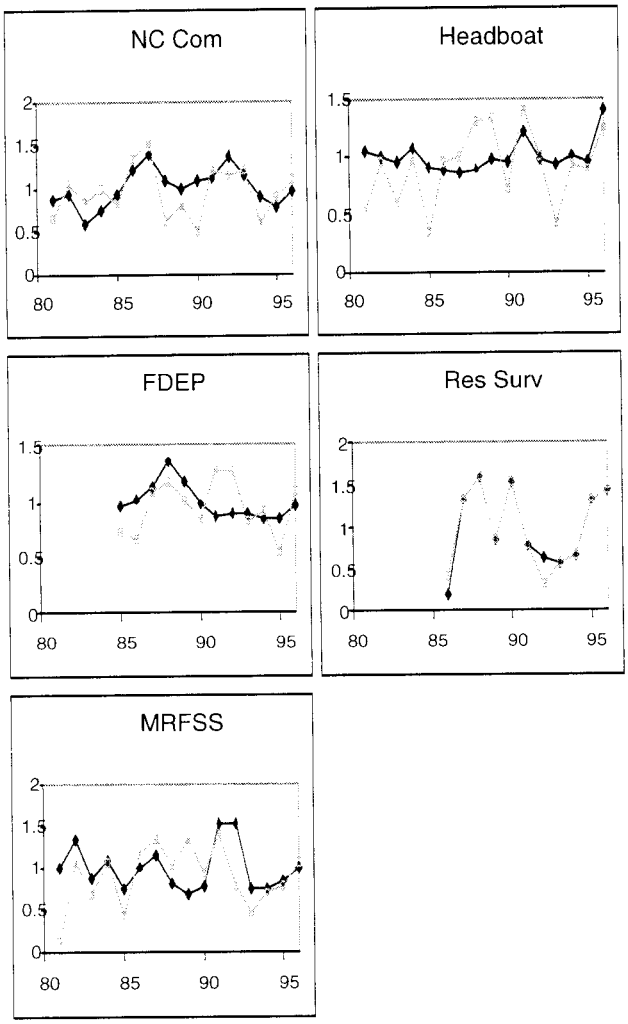

Figure 1c. Comparison of observed (filled diamonds) and predicted (open squares) indices for Atlantic king mackerel using Harris bycatch.

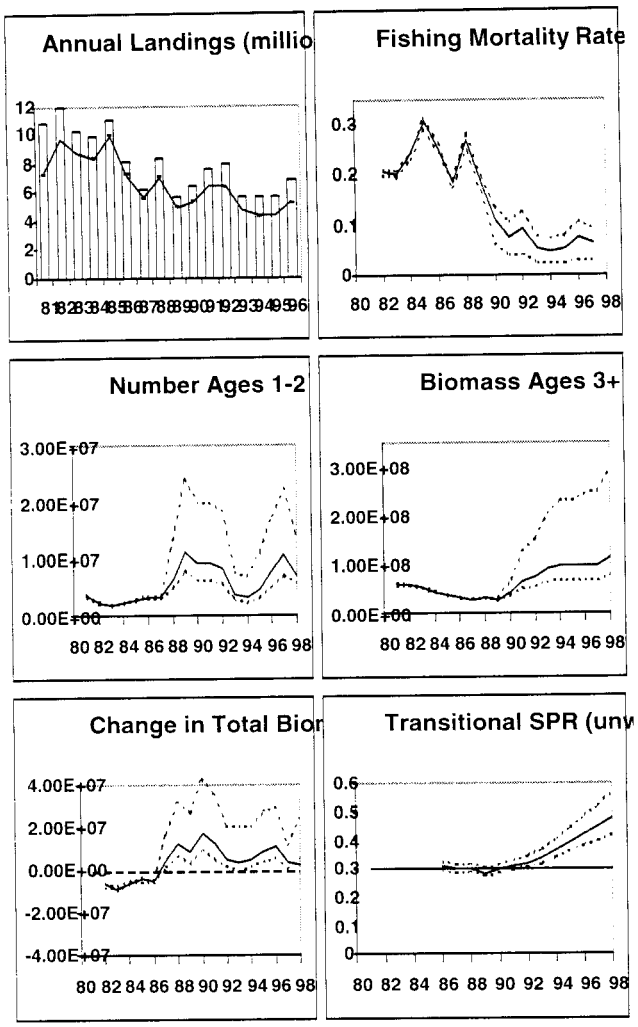

Figure 2a. Atlantic king mackerel catch and population trends with 80% bootstrap confidence intervals using Vaughan and Nance low bycatch.

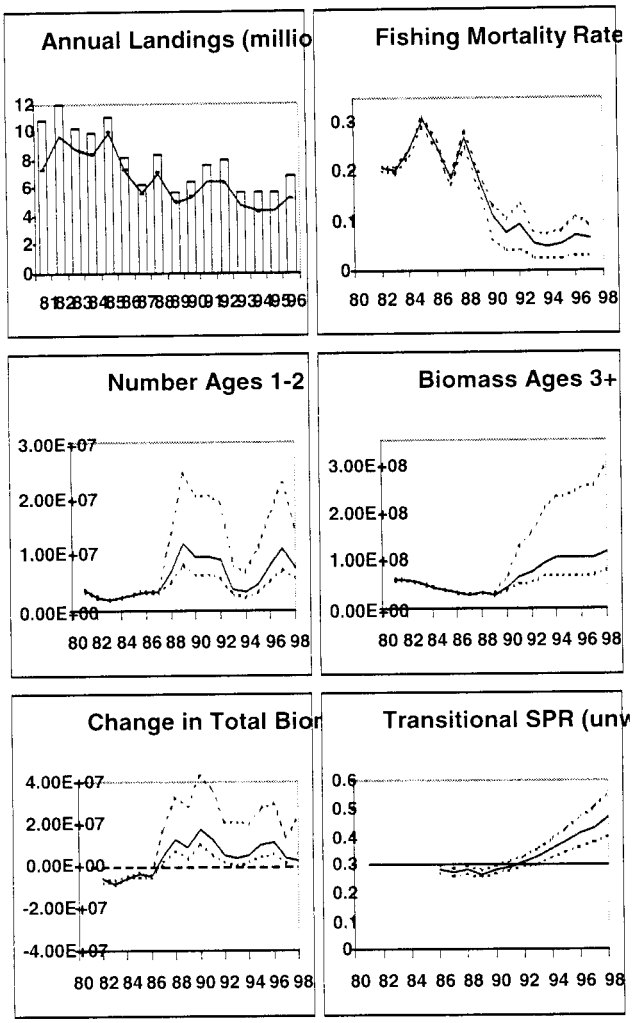

Figure 2b. Atlantic king mackerel catch and population trends with 80% bootstrap confidence intervals using Vaughan and Nance high bycatch.

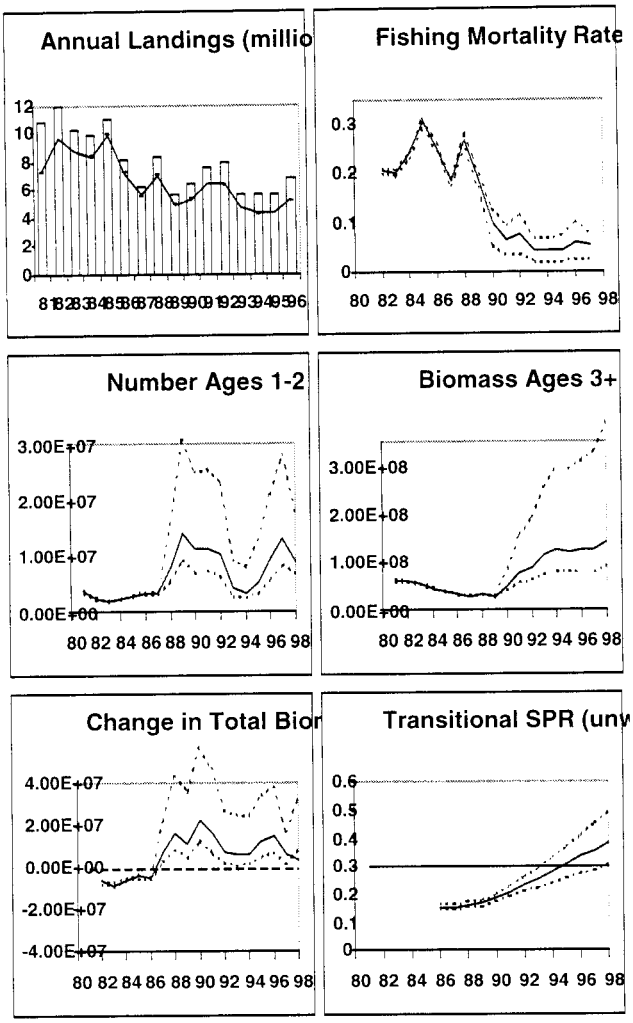

Figure 2c. Atlantic king mackerel catch and population trends with 80% bootstrap confidence intervals using Harris bycatch.

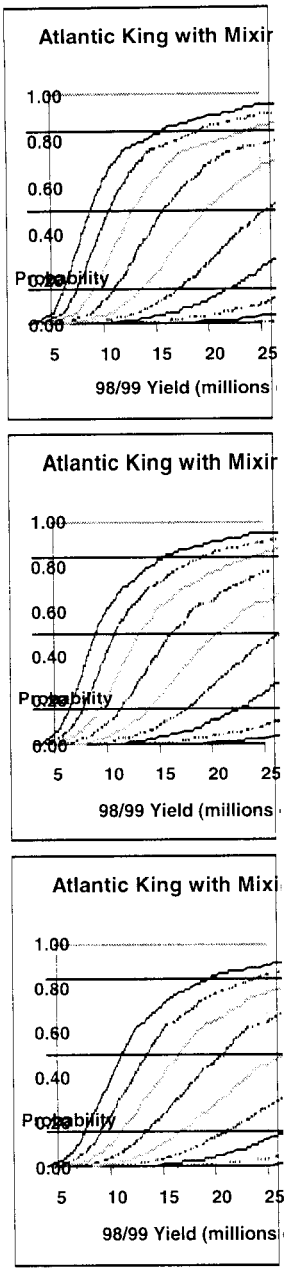

Figure 3. Probability of exceeding various spawning potential ratios under range of yields in the 1998/99 fishing season for Atlantic king mackerel. The spawning potential ratios range from 50% (the leftmost curve) to 5% (the rightmost curve, if visible at all) in increments of 5%. The two bolded lines are 40% SPR and 30% SPR. The horizontal lines denote the 16%, 50% and 84% risks.

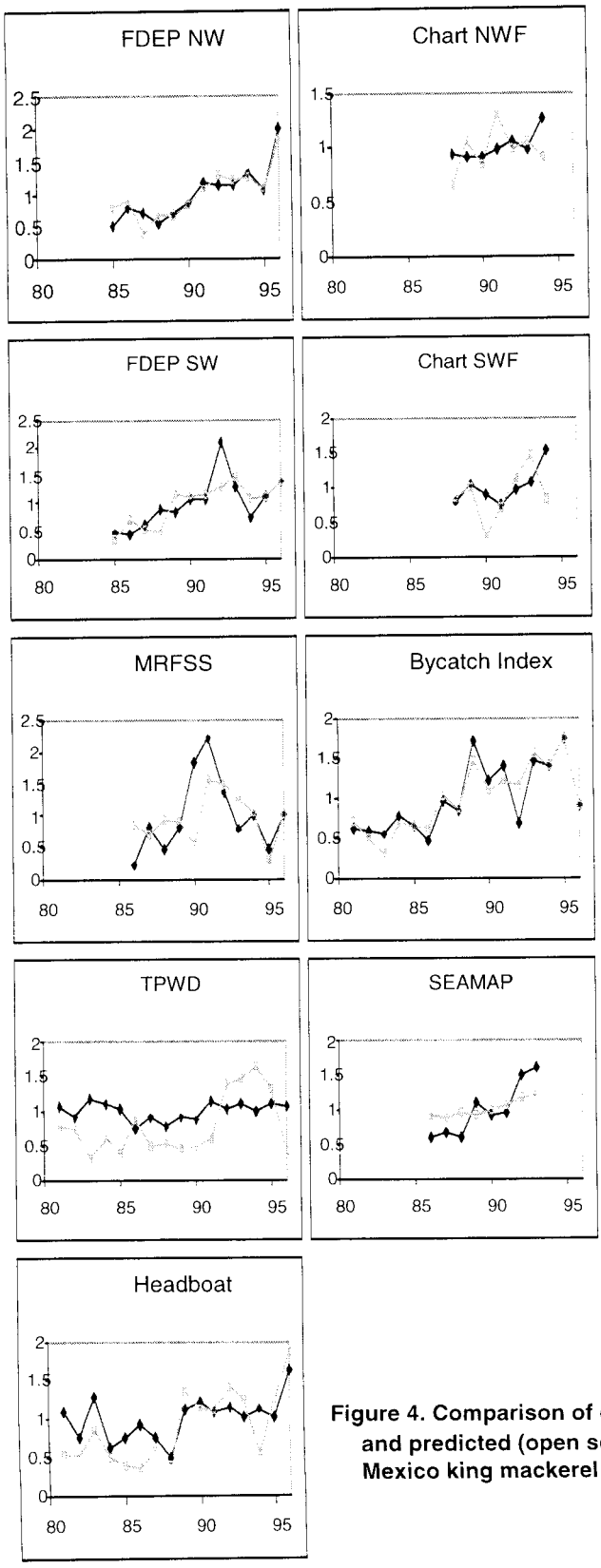

Figure 4. Comparison of c
and predicted (open sc
Mexico king mackerel

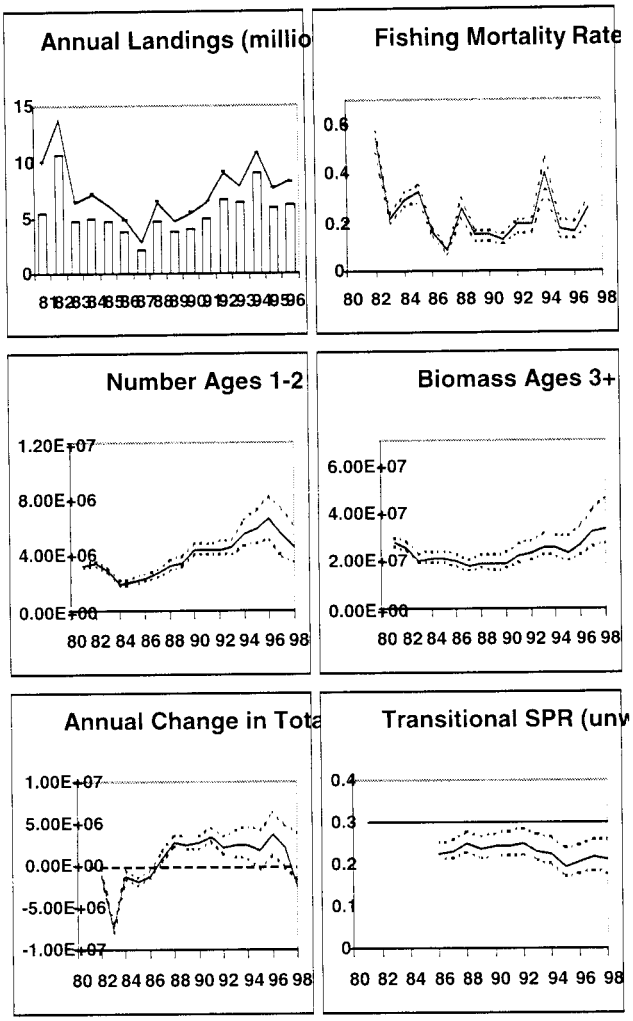

Figure 5. Gulf of Mexico king mackerel catch and population trends with 80% bootstrap confidence intervals.

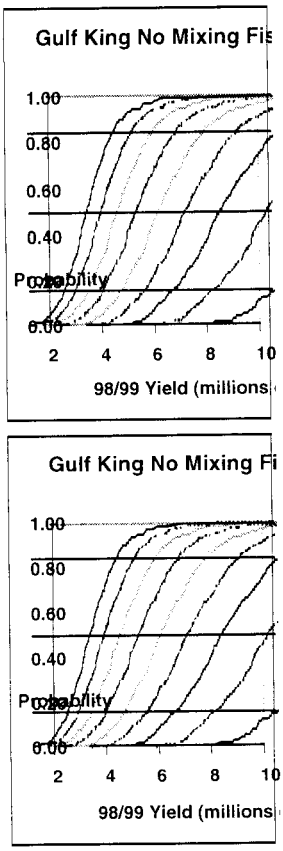

Figure 6. Probability of exceeding various spawning potential ratios under range of yields in the 1998/99 fishing season for Gulf of Mexico king mackerel. The spawning potential ratios range from 50% (the leftmost curve) to 5% (the rightmost curve, if visible at all) in increments of 5%. The two bolded lines are 40% SPR and 30% SPR. The horizontal lines denote the 16%, 50% and 84% risks.