Updated Information on the Otolith Ageing Data Used in the 2003 King and Spanish Mackerel Stock Assessment Analyses

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Introduction

Annual stock assessments of mackerel stocks in the southeastern US have been conducted since 1983. The earliest stock evaluations employed stock production models (see Powers and Eldridge 1983a, 1983b). Since 1985 investigations of the stock status have utilized age-based population models (e.g., virtual population analysis (VPA)) (see Nichols 1985, 1986). Age-based assessments require as input information on the total catch at age. Samples of mackerel age composition exist for catches since 1986 for king mackerel and since 1987 for Spanish mackerel stocks. Deterministic growth curves were applied to catch at size to estimate catch at age where direct age composition samples were not available through 1988 (see Scott and Burn 1987, 1988). The application of age length keys (i.e., direct age composition samples or ALK's) has been the preferred method to convert catch at size to catch at age in cases where sufficient age data exist (see Mackerel Stock Assessment Panel (MSAP 1989, MSAP 1997)). Cummings and DeVries (2002) provided an extensive background of the historical procedures adopted by the MSAP in 1989 to estimate catch at age where age observations did not exist (1985 and earlier for king and 1986 and earlier for Spanish) or were considered not sufficient for a migratory group, a calendar year, or a sex stratum (MSAP 1989). In cases where ALK's were not available the stochastic method described by Shepherd (1985) was used. These procedures were reviewed by later assessment panels (MSAP 1996, 1997). This report gives additional information on the available otolith ageing data for mackerel for the 2003 stock assessment for use in constructing age length keys (ALK's) and notes other pertinent details applicable to the 2003 stock assessment.

Available Otolith Ageing Data for Mackerel stocks in the southeastern U.S.

Field Collections

As noted in Cummings and DeVries (2002) since 1986 collections of otoliths have been ongoing for mackerel stocks under the technical guidance and funding of the National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center in Miami, Florida. This data collection effort, in addition to major cooperative efforts of other conservation agencies (e.g., North Carolina Division of Marine Resources (NDCMR), Florida Fish and Wildlife Commissin (FMRI), Virginia Division of Marine Resources(FDMR), MARFIN) has resulted in >45,000 thousand individual otolith observations being collected for mackerel stocks in the southeastern U.S., >30000 king and >15000 Spanish mackerel since 1986.

Age Determinations

Standard laboratory procedures,outlined in DeVries and Grimes (1997), have been utilized over the entire time period, 1986-2003, to make individual age determinations of mackerel hardparts. These methods have included quality control testing both within and among agencies to insure consistency in ageing criteria used; all of the mackerel age readings being used in stock assessments have been made by NMFS age readers.

Results of Updating the Otolith Data for the 2003 Mackerel Stock Assessment

King Mackerel Available Data

As in all previous assessment years in which a complete stock assessment was conducted, the king mackerel otolith ageing database was updated. A breakdown by migratory group, calendar year, and within year period (i.e., quarter) is given in Table 1. The strata recommended by the Mackerel Stock assessment Panel (MSAP) in 1989 to be used in deriving age length keys were migratory group, calendar year and sex. These strata reflected the primary partitions of the ageing data the Panel felt should be maintained separately in deriving annual ALK's. Sex was important as growth was shown by earlier investigators to vary between sexes for both species. Although within year stratification (e.g., month or quarter) was recognized as important, historically the available age data had been insufficient to allow derivation of separate ALK's by quarter of the year. The breakdown presented here includes these strata: migratory group, sex, and calendar year as well as within year sample sizes.

Catches Aged and Methods Used

The last full assessment for the Atlantic king mackerel stock was in 1998, and which incorporated ageing data from 1986 through1997. Age composition samples do not exist prior to 1986. In the previous 2002 Gulf king mackerel stock assessment a brief review of the ageing data provided by the NMFS, Panama City Laboratory revealed confounding in the area designation for a number of observations (Cummings and DeVries 2002). At the time of that assessment, the complete database was reviewed for both species and all migratory groups and the observations corrected to accurately identify the geographical area of collection. These corrections involved the ALK's built for 1995-1997 calendar years and were done for both the Gulf and Atlantic migratory groups at the time of the 2002 stock assessment (Table 2). At the time of the 2002 assessment, the Atlantic stock was not evaluated so the new (revised) ALK's were not used. ALK's for the Atlantic king mackerel group were maintained in the 2003 assessment for the 1986-1994 calendar years as last used in the 2000 Atlantic stock assessment. A complete review of the entire king mackerel database, including catches, length samples, ageing samples was conducted for the 1996 stock assessment which utilized data for 1986 through the 1994 fishing year.

As 1998 was the last full assessment for the Atlantic king mackerel stock, ageing data was both revised and new data added for the 2003 assessment. As noted above, otolith observations for calendar years 1995-1997 were corrected for area coding errors. Much new otolith data were added: the 1998 and 1999 data were completely replaced and new data for 2000, 2001, and 2002 were added for the 2003 assessment. Thus, for use in the 2003 stock assessment, ALK's were revised for 1995-1998 calendar years and new ALK's were calculated for 1999, 2000, and 2001 calendar years. Data were considered insufficient for the calendar year 2002 to construct an ALK (Table 3).

Spanish Mackerel Available Data

As with king mackerel, in all previous assessment years in which a complete stock assessment was conducted the Spanish mackerel otolith ageing database was updated. A breakdown by migratory group, calendar year, and within year quarter is given in Table 4. As for the king mackerel, similar stratifications were adopted by the MSAP in 1989 for use in calculating ALK's for Spanish mackerel. Although, finer time stratifications may be important in tracking individual cohorts, the 1989 Panel did not feel quarter of the year was as critical as in king mackerel. The within year data breakdown of the ageing data is provided here in order to review the yearly sampling of this species in the southeastern U.S. for age composition. Additionally, catch temporal resolution is maintained at the month level so finer partitioning of ALK's could be made if desired.

Catches Aged and Methods Used

As in Atlantic king mackerel, the last year in which a complete stock assessment was conducted for Spanish mackerel stocks was in 1998. That assessment utilized ageing data from 1987 through 1997 (fishing year 1996). Direct age composition samples of Spanish mackerel are not available prior to 1987 in sufficient numbers to construct annual sex specific ALK's. The same procedures used to update the king mackerel ageing database were employed for the Spanish mackerel dataset. Similarly, it was necessary to review the entire dataset for two main reasons 1) to account for confounding in area coding that had been identified in the king mackerel observation set and 2) to thoroughly review the data since the last full review of the ageing observations had been in the 1998 assessment using data through 1996/1997 fishing year. The problem of area coding was found to not be as large in the Spanish mackerel data set (Table 5).

The complete updated ageing dataset used in the 2003 Spanish mackerel analyses thus used ALK's as derived through the 1998 assessment year for calendar years 1987-1994. ALK's for 1995-1997 were recalculated for the 2003 stock assessment. As for Atlantic king mackerel much new data were added and several years replaced. Data for calendar year 1998 and 1999 was replaced, data for calendar years 2000, 2001 and for 2002 were added new since the 1998 assessment. Thus, ALK's were revised for 1995-1999 and added as new for the 2000 and 2001 calendar years (Table 6)

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Table 1. Number of otolith observations available for king mackerel for the 2003 stock assessment (Data complete through 2001).).

Mig	Sex	Calendar Year	Jan-Mar	April-June	July-Sept	Oct-Dec	All
ATL	M	1986	0	56	123	3	182
ATL	M	1987	0	100	46	59	205
ATL	M	1988	0	133	58	5	196
ATL	M	1989	0	36	189	114	339
ATL	M	1990	9	71	207	63	350
ATL	M	1991	23	35	142	79	279
ATL	M	1992	22	93	267	96	478
ATL	M	1993	49	178	86	40	353
ATL	M	1994	33	134	199	42	408
ATL	M	1995	13	188	75	19	295
ATL	M	1996	7	168	46	46	267
ATL	M	1997	0	62	119	44	225
ATL	M	1998	25	90	112	43	270
ATL	M	1999	13	201	106	52	372
ATL	M	2000	12	48	132	42	234
ATL	M	2001	0	84	138	49	271
ATL	M	2002	11	1	0	0	12
ATL	F	1986	0	76	120	7	203
ATL	F	1987	0	113	108	72	293
ATL	F	1988	0	167	82	1	250
ATL	F	1989	0	112	290	95	497
ATL	F	1990	10	150	320	96	576
ATL	F	1991	37	84	303	103	527
ATL	F	1992	9	168	466	156	799
ATL	F	1993	75	252	159	65	551
ATL	F	1994	53	135	233	62	483
ATL	F	1995	14	161	144	34	353
ATL	F	1996	12	298	327	64	701
ATL	F	1997	0	52	174	57	283
ATL	F	1998	37	201	215	92	545
ATL	F	1999	19	215	196	73	503
ATL	F	2000	14	98	284	80	476
ATL	F	2001	0	204	249	97	550
ATL	F	2002	14	1	0	0	15

Table 1. (continued).

Mig	Sex	Calendar Year	Jan-Mar	April-June	Quarter of Year July-Sept	Oct-Dec	All
EG	M	1986	0	0	51	2	53
EG	M	1987	18	65	74	7	164
EG	M	1988	0	10	79	8	97
EG	M	1989	18	14	126	13	171
EG	M	1990	23	45	65	25	158
EG	M	1991	10	123	216	25	374
EG	M	1992	45	97	159	18	319
EG	M	1993	37	46	254	42	379
EG	M	1994	15	57	119	72	263
EG	M	1995	24	59	81	134	298
EG	M	1996	102	97	104	77	380
EG	M	1997	195	40	71	48	354
EG	M	1998	118	20	16	67	221
EG	M	1999	58	35	47	56	196
EG	M	2000	67	9	20	76	172
EG	M	2001	482	4	117	169	772
EG	M	2002	443	41	0	0	484
EG	F	1986	0	0	153	2	155
EG	F	1987	29	132	241	25	427
EG	F	1988	0	29	223	16	268
EG	F	1989	15	33	248	23	319
EG	F	1990	28	67	173	30	298
EG	F	1991	45	224	345	235	849
EG	F	1992	73	143	419	98	733
EG	F	1993	33	194	409	138	774
EG	F	1994	13	204	307	133	657
EG	F	1995	17	187	226	298	728
EG	F	1996	193	222	369	587	1371
EG	F	1997	446	126	209	75	856
EG	F	1998	175	22	66	159	422
EG	F	1999	137	59	99	96	391
EG	F	2000	463	47	87	122	719
EG	F	2001	622	5	145	169	941
EG	F	2002	535	92	0	0	627

Table 1. (continued).

Mig	Sex	Calendar Year	Jan-Mar	April-June	July-Sept	Oct-Dec	All
					Quarter of Year		
WG	M	1986	0	8	41	0	49
WG	M	1987	0	22	109	0	131
WG	M	1988	0	30	69	0	99
WG	M	1989	0	47	60	3	110
WG	M	1990	0	53	28	7	88
WG	M	1991	0	10	114	1	125
WG	M	1992	0	43	96	1	140
WG	M	1993	0	10	53	5	68
WG	M	1994	0	6	25	0	31
WG	M	1995	0	0	0	0	0
WG	M	1996	0	0	0	0	0
WG	M	1997	0	0	0	0	0
WG	M	1998	0	0	0	0	0
WG	M	1999	0	0	0	0	0
WG	M	2000	0	0	0	0	0
WG	M	2001	0	0	0	0	0
WG	M	2002	0	0	0	0	0
WG	F	1986	0	9	40	1	50
WG	F	1987	0	47	156	0	203
WG	F	1988	0	85	135	0	220
WG	F	1989	0	86	116	43	245
WG	F	1990	0	76	65	7	148
WG	F	1991	0	64	188	0	252
WG	F	1992	0	96	100	25	221
WG	F	1993	0	12	55	5	72
WG	F	1994	0	18	31	0	49
WG	F	1995	0	0	0	0	0
WG	F	1996	0	0	0	0	0
WG	F	1997	0	0	0	0	0
WG	F	1998	0	0	0	0	0
WG	F	1999	0	0	0	0	0
WG	F	2000	0	0	0	0	0
WG	F	2001	0	0	0	0	0
WG	F	2002	0	0	0	0	0

Table 2a. Summary of the number of additional Atlantic mackerel mackerel
           ageing available for the MSAP 2003 stock assessment vs the 1998
           stock assessment.

Mig	1995	1996	1997
Atlantic	+216 quarter 2	+ 8 quarter 2	+ 96 quarter 2

Table 3. Ageing protocol used to transform Atlantic king mackerel catch at
         length to catch at age in the 2003 stock assessment for catches
         either revised (1995-1998) or added new.

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             Calendar        Quarter of Year
Mig      Sex  Year  Jan-Mar April-June July-Sept  Oct-Dec
--------------------------------------------------------------
Atlantic  M   1995   STO      ALK       ALK        ALK
          F   1995   STO      ALK       ALK        ALK

Atlantic  M   1996   STO      ALK       ALK        ALK
          F   1996   STO      ALK       ALK        ALK

Atlantic  M   1997   STO      ALK       ALK        ALK
          F   1997   STO      ALK       ALK        ALK

Atlantic  M   1998   ALK      ALK       ALK        STO
          F   1998   ALK      ALK       ALK        STO

Atlantic  M   1999   STO      ALK       ALK        ALK
          F   1999   STO      ALK       ALK        ALK

Atlantic  M   2000   STO      ALK       ALK        ALK
          F   2000   STO      ALK       ALK        ALK


Atlantic  M   2001   STO      ALK       ALK        ALK
          F   2001   STO      ALK       ALK        ALK

Atlantic  M   2002   STO      STO       STO        STO
          F   2002   STO      STO       STO        STO


ALK= Age Length Key
STO= Stochastic Ageing Method (Shepherd 1985)
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Table 4. Number of otolith observations available for Spanish mackerel for the 2003 stock assessment (Data are complete through 2001)

| | | | Quarter of Year | | | | |
Mig	Sex	Calendar Year	Jan-Mar	April-June	July-Sept	Oct-Dec	All
ATL	M	1986	0	0	0	0	0
ATL	M	1987	29	36	8	0	73
ATL	M	1988	0	54	7	0	61
ATL	M	1989	0	6	77	0	83
ATL	M	1990	11	91	67	16	185
ATL	M	1991	18	55	148	30	251
ATL	M	1992	20	96	93	25	234
ATL	M	1993	13	66	41	22	142
ATL	M	1994	0	34	65	13	112
ATL	M	1995	4	31	20	65	120
ATL	M	1996	0	108	32	66	206
ATL	M	1997	23	48	141	53	265
ATL	M	1998	11	63	74	149	297
ATL	M	1999	79	59	56	122	316
ATL	M	2000	85	101	49	114	349
ATL	M	2001	83	71	55	75	284
ATL	M	2002	80	0	0	0	80
ATL	F	1986	0	0	0	0	0
ATL	F	1987	57	54	59	3	173
ATL	F	1988	0	78	35	0	113
ATL	F	1989	0	19	110	0	129
ATL	F	1990	31	141	132	18	322
ATL	F	1991	8	37	260	69	374
ATL	F	1992	28	141	206	72	447
ATL	F	1993	64	107	78	60	309
ATL	F	1994	3	22	51	12	88
ATL	F	1995	9	39	51	109	208
ATL	F	1996	0	148	67	143	358
ATL	F	1997	17	68	176	106	367
ATL	F	1998	11	44	127	225	407
ATL	F	1999	78	87	82	148	395
ATL	F	2000	97	153	302	130	682
ATL	F	2001	82	149	151	118	500
ATL	F	2002	73	0	0	0	73

Table 4. (continued).

Mig	Sex	Calendar Year	Quarter of Year Jan-Mar	April-June	July-Sept	Oct-Dec	All
EG	M	1986	0	0	0	0	0
EG	M	1987	4	52	31	3	90
EG	M	1988	38	67	9	0	114
EG	M	1989	35	49	51	6	141
EG	M	1990	162	193	61	17	433
EG	M	1991	31	106	40	54	231
EG	M	1992	278	83	8	4	373
EG	M	1993	34	63	22	3	122
EG	M	1994	149	30	4	6	189
EG	M	1995	63	16	22	15	116
EG	M	1996	51	62	24	12	149
EG	M	1997	6	17	5	9	37
EG	M	1998	10	23	23	2	58
EG	M	1999	8	40	147	2	197
EG	M	2000	22	30	16	0	68
EG	M	2001	48	16	11	9	84
EG	M	2002	25	0	0	0	25
EG	F	1986	0	0	0	0	0
EG	F	1987	11	79	91	33	214
EG	F	1988	15	77	50	3	145
EG	F	1989	35	68	97	9	209
EG	F	1990	98	185	215	32	530
EG	F	1991	76	207	189	67	539
EG	F	1992	330	165	73	12	580
EG	F	1993	49	57	115	10	231
EG	F	1994	256	86	68	13	423
EG	F	1995	168	17	108	27	320
EG	F	1996	200	73	66	44	383
EG	F	1997	1	36	24	23	84
EG	F	1998	3	34	47	16	100
EG	F	1999	11	67	279	7	364
EG	F	2000	29	53	31	1	114
EG	F	2001	44	40	22	16	122
EG	F	2002	25	0	0	0	25

Table 4. (continued).

Mig	Sex	Calendar Year	Jan-Mar	April-June	July-Sept	Oct-Dec	All
				Quarter of Year			
WG	M	1986	0	0	0	0	0
WG	M	1987	0	7	26	0	33
WG	M	1988	0	6	5	0	11
WG	M	1989	0	1	52	1	54
WG	M	1990	0	2	17	1	20
WG	M	1991	0	0	32	0	32
WG	M	1992	0	0	17	0	17
WG	M	1993	0	0	1	0	1
WG	M	1994	0	0	0	0	0
WG	M	1995	0	0	0	0	0
WG	M	1996	0	0	0	0	0
WG	M	1997	0	0	0	0	0
WG	M	1998	0	0	0	0	0
WG	M	1999	0	0	0	0	0
WG	M	2000	0	0	0	0	0
WG	M	2001	0	0	0	0	0
WG	M	2002	0	0	0	0	0
WG	F	1986	0	0	0	0	0
WG	F	1987	0	1	40	0	41
WG	F	1988	0	3	3	0	6
WG	F	1989	0	1	68	6	75
WG	F	1990	0	1	27	8	36
WG	F	1991	0	0	67	2	69
WG	F	1992	0	1	16	0	17
WG	F	1993	0	0	4	0	4
WG	F	1994	0	0	0	0	0
WG	F	1995	0	0	0	0	0
WG	F	1996	0	0	0	0	0
WG	F	1997	0	0	0	0	0
WG	F	1998	0	0	0	0	0
WG	F	1999	0	0	0	0	0
WG	F	2000	0	0	0	0	0
WG	F	2001	0	0	0	0	0
WG	F	2002	0	0	0	0	0

Table 5a.   Summary of the number of additional Spanish mackerel ageing
             observations available for the MSAP 2003 stock assessment as
             reviewed vs the MSAP 1998 stock assessment.

Mig	1995	1996	1997
Atlantic	+34	+ 0	+ 0
Gulf	+ 2	+266	+ 0
Total # Additional	**+ 36**	**+266**	**+ 0**

Table 5b. Quarter of year affected by corrections of area in the 1995-1997 Spanish mackerel ageing
           data.

Year	Atlantic	Gulf
1995	+34 quarter 4	+ 2 quarter
1996	+ 0	+ 266 quarter 1
1997	+ 0	+ 0

Table 6. Ageing protocol used to transform Spanish mackerel catch at length to catch at age for catches either revised (1995-
1998) or added new (2001-2002 for the 2003 mackerel stock assessment.

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                Calendar            Quarter of Year
 Mig     Sex    Year    Jan-Mar April-June July-Sept  Oct-Dec
---------------------------------------------------------------------
Atlantic  M     1995     ALK       ALK        ALK       ALK
          F     1995     ALK       ALK        ALK       ALK

Atlantic  M     1996     ALK       ALK        ALK       ALK
          F     1996     ALK       ALK        ALK       ALK

Atlantic  M     1997     ALK       ALK        ALK       ALK
          F     1997     ALK       ALK        ALK       ALK

Atlantic  M     1998     ALK       ALK        ALK       ALK
          F     1998     ALK       ALK        ALK       ALK

Atlantic  M     1999     ALK       ALK        ALK       ALK
          F     1999     ALK       ALK        ALK       ALK

Atlantic  M     2000     ALK       ALK        ALK       ALK
          F     2000     ALK       ALK        ALK       ALK

Atlantic  M     2001     ALK       ALK        ALK       ALK
          F     2001     ALK       ALK        ALK       ALK

Atlantic  M     2002     STO       STO        STO       STO
          F     2002     STO       STO        STO       STO



GULF      M     1995     ALK       ALK        ALK       ALK
          F     1995     ALK       ALK        ALK       ALK

GULF      M     1996     ALK       ALK        ALK       ALK
          F     1996     ALK       ALK        ALK       ALK

GULF      M     1997     STO       STO        STO       STO
          F     1997     STO       STO        STO       STO

GULF      M     1998     STO       STO        STO       STO
          F     1998     STO       STO        STO       STO

GULF      M     1999     ALK       ALK        ALK       ALK
          F     1999     ALK       ALK        ALK       ALK

GULF      M     2000     STO       STO        STO       STO
          F     2000     STO       STO        STO       STO

GULF      M     2001     STO       STO        STO       STO
          F     2001     STO       STO        STO       STO

GULF      M     2002     STO       STO        STO       STO
          F     2002     STO       STO        STO       STO
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ALK = Age Length Key
STO = Stochastic Method (Shepherd 1985)
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