# Length frequency distributions for king mackerels in the Gulf of Mexico and South Atlantics from 1978-2013

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## Length frequency distributions for king mackerels in the Gulf of Mexico and South Atlantics from 1978-2013

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## Introduction

This report documents changes in the length frequency distributions (LFDs) of king mackerels collected from the Gulf of Mexico (GOM) and the South Atlantic (ATL) from 1978 to 2013. Methods for estimating LFDs for king mackerels in SEDAR 38 differ from those used in SEDAR 16 in several ways : (1) the stock definitions for GOM and ATL have been significantly changed, (2) fishing areas, instead of landing areas, have been used when available, and (3) LFDs for two new strata (gill net and tournament samples) have been estimated. In this document, LFDs for the winter mixing zone (WMZ) were not estimated due to inadequate length sample sizes for the WMZ (see below for details).

## Materials and Methods

Length samples for commercial fisheries were obtained from the Trip Interview Program (TIP) database and the Gulf FIN database. Commercial data were grouped into 3 strata: (1) handline (HL), (2) gill net (GN) and (3) other gear types (OT). Length samples for recreational fisheries were obtained from the Marine Recreational Fisheries Statistics Survey (i.e., the Marine Recreational Information Program, MRIP), the Head Boat Survey, the Texas Parks and Wildlife Department database, the Gulf FIN database, and the TIP database. Recreational length data were grouped into four strata: (1) charter boat (CP), (2) head boat (HB), (3) private boat and shore (PR), and tournament (TRN).

The definition of GOM/ATL stocks has been changed significantly for SEDAR 38 as compared to SEDAR 16 (Mauricio, 2008), based on new information of the mixing dynamics among king mackerel migratory contingents. The new mixing zone is now defined as the area south of the Florida Keys and Dry Tortugas, demarcated in the west by a line from Key West to the Dry Tortugas, then south from the Dry Tortugas to the shelf edge and in the east from the Miami-Dade-Monroe county line to the shelf edge (for details, see SEDAR 38 DW report). King mackerels caught in the mixing zone from 11/1-3/31 are defined as landings/samples from the winter mixing zone (WMZ). King mackerels caught in the mixing zone from 4/1-10/31 are considered as landings/samples from the ATL stock.

In contrast to SEDAR 16, fishing area, instead of landing area, was used to assign king mackerels to different regions and stocks. When fishing area was not available, then the landing area was used. Use of fishing area was particularly critical in assigning samples from Monroe County to different stocks. Commercial samples from the Monroe County area were assigned to different stocks based on the following rules: king mackerels caught from areas 1.1,1.8, 2.0, 2.8, 744.1, and 748.1 were assigned to the Gulf stock, while fish caught from areas 1.0, 1.9, 2.2, 2.9, 748.0, and 748.9 were assigned to the mixing zone. Samples that were caught from areas 12 and 17 in the Head Boat Survey were assigned to the mixing zone. Samples caught from Monroe County in the MRIP database were assigned to the mixing zone.

LFDs were estimated for fishing year instead of calendar year. The fishing year for the ATL stock was defined as 4/1 to 3/31, while the fishing year for the GOM stock was defined as 7/1 to 6/30.

All length values in the original data sets were converted to fork lengths with the following equations:

Fork length= -4.280 +0.963\*total length (in centimeters), n=2034,  $r^2$ =0.99; Fork length= 0.663 +1.051\*standard length (in centimeters), n=2083,  $r^2$ =0.99;

Length samples were grouped into 5 cm intervals (e.g., if  $50 \le \text{length} < 55$  then length=50) so that they coincided with the length intervals used in age-length keys for king mackerels.

In this document, LFDs were estimated for the GOM and ATL stocks, but not for the WMZ, for the following reasons: (a) length sample sizes from the WMZ for most strata/fishing years were small (Table 1-5), (b) landings from the WMZ represented only a small proportion of the total landings (e.g., approximately 5% for commercial landings), (c) length samples from the mixing zone cannot be assigned to individual stock so that partitioning of LFDs from the WMZ may introduce bias into the LFDs of the ATL/GOM stocks, and (d) no evidence exists that LFDs for the GOM/ATL king mackerels in the WMZ are different from the LFDs for the GOM/ATL king mackerels in the GOM/ATL.

#### Results and Discussion

#### Sample sizes

Length samples collected from several strata (e.g., OT, TRN) had sample sizes that were too small for LFD estimation in many fishing years (Tables 1-5). Only LFDs estimated from those strata/fishing years that had sample sizes larger than or equal to 50 are shown in Figs 4-10. Sample sizes for commercial handline and gill net fisheries were large for most years. However, effective sample sizes could be much smaller than actual sample sizes due to clustering effects. A previous study (Chih, 2009) showed that length samples collected from commercial fisheries in the Gulf of Mexico had large

design effects (deff) caused by cluster sampling (deff= 3.2-3.3 for HL, deff=6.7-7.9 for GN, deff=3.9-4.4 for Trolling). That is, the effective sample size often was only 12-30% of the actual sample size. The design effects for recreational samples were not estimated due to lack of trip information. The precision in LFDs can decrease drastically when effective sample sizes fall significantly below 500. Thus, effective sample sizes, rather than actual sample sizes, need to be taken into consideration when LFDs are weighted in assessment models.

## Comparisons of LFDs among stocks

There was considerable variation in LFDs between ATL and GOM stocks. For example, length samples from commercial hand line fisheries had higher proportions of larger fish in the GOM than those taken from the ATL in most years, particularly in early years (Fig 4, (a)-(d)). Those differences in LFDs were also reflected in differences in mean lengths (Fig 1(b)). Also, length samples from recreational head boats, private boats and tournament fishing had higher proportions of larger fish in GOM than in ATL for most years (Figs 9-10). Those differences in LFDs for recreational samples among the two stocks were also reflected in differences in mean lengths (Fig 3(b)-(d)).

The differences in LFDs/mean lengths among the two stocks may be due to differences in year class strengths, growth, fishing practices or other environmental factors which affected age/size selectivity. Also, the fishing years for the two stocks were different, which may have also contributed to the differences in the estimated LFDs/mean lengths between the two stocks from the same year.

## Comparisons of LFDs among strata

There were noticeable differences in LFDs and mean lengths estimated from different strata. For example, LFDs and mean lengths estimated from the commercial gill net fishery were different from those estimated from the commercial handline fishery, with the mean lengths from handline samples being larger than those estimated from gill net samples for most years (Fig 1(a)). Also, the dispersion in LFDs and mean lengths estimated from tournament samples were noticeably different from those estimated from other recreational fisheries (Fig 2 (a),(b)). These differences in LFDs/mean lengths were most likely due to differences in gill selectivity (commercial samples) and in fishing behavior (recreational fisheries).

## Comparisons of LFDs among different fishing years

There were noticeable differences in LFDs and mean lengths estimated from different fishing years within the same stratum. For example, mean lengths for hand line samples from early years (before 1991) were noticeably larger than those estimated from later years. The dispersion in LFDs also changed considerably between fishing years. Changes in fishing regulations (size limit changes in 1990, 1992, 1999) did not

seem to affect mean length significantly. These changes in LFDs dispersion may reflect differences in year-class strength, age/size selectivity, growth and other environmental factors between different fishing years.

## <u>References</u>

Chih, Ching-Ping, 2009. Evaluation of the sampling efficiency of three otolith sampling methods for commercial King Mackerel fisheries. Transactions of the American Fisheries Society 138:990-999.

Ortiz, Mauricio, 2008. Review of catch, catch at size, sex ratios and catch at age of king mackerel from the U.S. Gulf of Mexico and South Atlantic fisheries. SEDAR 16-DW-28.

Table 1. Sample sizes for king mackerel length samples collected from commercial fisheries from 1983 to 2013. Stocks: Atlantic (ATL), Gulf of Mexico (GOM), WMZ (winter mixing zone), Gear types: Hand line (HL), Gill net (GN), Other gears (OT).

Fishing Year		ATL		GOM			WMZ		
	GN	HL	ОТ	GN	HL	ОТ	GN	HL	ОТ
1983		26			7143				
1984	614	6658	794	921	13919	2	22	95	
1985	32	8071	2	1477	3841	7	11	38	
1986	251	5199	4	290	981			139	
1987	3577	2637	3	1	1795			2	
1988	1905	3120		105	395	13	450		
1989	1038	3269	253	351	1958		50	71	
1990		7320	1	124	506	8		20	
1991	22	13182		179	2495	1		18	
1992	9	10506	22	838	4112	50	65	328	
1993	73	5992	35	525	1631	1	28	172	
1994	102	7625	3	983	2292	40		72	
1995	2	4918	9	1669	1609	5	1	867	1
1996	139	8323	3	537	1315	50		318	
1997	3	3250	7	1457	2006	8		684	
1998	7	8974	1	1431	1276	8	97	167	
1999	14	11654	17	1034	1618	29	223	263	
2000		9540	3	333	1322	16	99	147	
2001		8465	1	571	1376	11		23	1
2002		6267	9	950	1653	74	10	9	7
2003	1	5833	3	227	1177	69	85	39	
2004		4986	51	395	1163	25		235	
2005	1	2872	102	478	1102	2	36	205	
2006		3803	278	152	1204	1	40	13	9
2007	4	3058	357	539	997		23	74	
2008	109	5068	433	590	1032	15	55	56	
2009	54	7777	151	660	1276	31	124	134	
2010	85	5697	313	780	1061			198	
2011	18	4500	141	775	2882			96	
2012	97	3498	30	1148	3348	20		37	
2013	16	1629	1	5	3380	15			

Table 2. Sample sizes for king mackerel length samples collected from charter boat fishery from 1980 to 2013. Stocks: Atlantic (ATL), Gulf of Mexico (GOM), WMZ (winter mixing zone)

Fishing Year	ATL	GOM	WMZ
1980		45	
1981	88	9	10
1982	56	19	9
1983	107	180	56
1984	187	830	20
1985	156	181	5
1986	497	309	18
1987	1060	228	3
1988	824	270	
1989	943	133	34
1990	1214	243	69
1991	1170	1898	57
1992	1734	1663	183
1993	895	754	287
1994	840	718	396
1995	1090	652	416
1996	1456	652	180
1997	1345	914	1236
1998	1278	1000	749
1999	918	1855	242
2000	1643	2000	398
2001	1341	1586	310
2002	1435	1403	171
2003	1397	1099	206
2004	917	1161	86
2005	754	698	193
2006	764	1367	55
2007	677	1164	132
2008	667	965	85
2009	545	1591	75
2010	297	911	162
2011	229	1158	130
2012	168	874	122
2013	54	41	

Table 3. Sample sizes for king mackerel length samples collected from head boat fishery from 1978 to 2013. Stocks: Atlantic (ATL), Gulf of Mexico (GOM), WMZ (winter mixing zone)

Fishing Year	ATL	GOM	WMZ
1978	268		
1979	570		9
1980	735		85
1981	702		91
1982	416		65
1983	1169		186
1984	1138		99
1985	1167	102	4
1986	1295	247	34
1987	609	287	3
1988	460	274	
1989	609	440	78
1990	341	106	29
1991	574	948	9
1992	451	703	31
1993	552	622	17
1994	510	875	6
1995	410	724	33
1996	102	616	46
1997	1694	344	29
1998	712	285	9
1999	417	406	4
2000	552	264	18
2001	367	203	
2002	294	297	8
2003	790	166	2
2004	751	255	3
2005	971	248	35
2006	883	231	4
2007	834	141	1
2008	552	98	10
2009	551	107	15
2010	435	91	4
2011	207	155	76
2012	239	1302	20
2013	149	676	

Table 4. Sample sizes for king mackerel length samples collected from private boat and 'shore' fisheries from 1980 to 2013. Stocks: Atlantic (ATL), Gulf of Mexico (GOM), WMZ (winter mixing zone)

Fishing Year	ATL	GOM	WMZ
1980		2	
1981	54	32	1
1982	277	73	
1983	119	434	3
1984	115	1000	
1985	99	741	1
1986	357	665	38
1987	442	597	
1988	300	440	2
1989	279	451	3
1990	331	447	11
1991	547	1023	3
1992	448	708	6
1993	271	780	10
1994	263	748	5
1995	261	1312	6
1996	233	1096	18
1997	340	1193	1
1998	273	1085	10
1999	375	941	
2000	400	922	
2001	361	721	
2002	327	1006	1
2003	326	717	2
2004	174	917	
2005	213	1247	
2006	378	1194	1
2007	432	675	
2008	341	889	
2009	237	859	
2010	143	358	3
2011	86	934	
2012	114	503	
2013	42	26	

Table 5. Sample sizes for king mackerel length samples collected from fishing tournaments from 1983 to 2013. Stocks: Atlantic (ATL), Gulf of Mexico (GOM), WMZ (winter mixing zone)

Fishing Year	ATL	GOM	WMZ
1983		19	
1984	1815	37	
1985	379	33	
1986	342	126	
1987	597	224	
1988	539	327	
1989	1488	296	
1990	4585	154	
1991	4179	154	
1992	2397	1293	
1993	1205	881	
1994	734	864	
1995	239	275	
1996	418	94	197
1997	319	43	160
1998	899	164	6
1999	438	7	
2000	560	18	
2001	537	29	
2002	337	195	
2003	980	311	
2004	364	124	
2005	185	52	
2006	122	29	
2007	235		
2008	246		
2009	200		
2010	259	52	9
2011	286	87	
2012	362		

Fig 1. Mean lengths for king mackerel length samples collected from commercial fisheries from 1984 to 2013 (only those years with sample sizes greater than or equal to 50 were included).



(a) Handline (HL) vs gill net (GN)



(b) Handline, ATL vs GOM

Fig 2. Mean lengths for king mackerel length samples collected from recreational fisheries from 1984 to 2013 (only those years with sample sizes greater than or equal to 50 were included, CP-charter boat, HB- head boat, PR-private boat, TRN- tournament).



(b) ATL



King mackerel, mean fork length, ATL, Recreational

Fig 3. Mean lengths for king mackerel length samples collected from recreational fisheries from 1984 to 2013 (only those years with sample sizes greater than or equal to 50 were included).

(a) Charter boat



(b) Head boat



Fig 4. Mean lengths for king mackerel length samples collected from recreational fisheries from 1984 to 2013 (only those years with sample sizes greater than or equal to 50 were included).



(c) Private boat

(d) Tournament fishing



King mackerel, mean fork length, Tournament samples

Fig 5 (a). Length frequency distributions for king mackerel length samples collected from commercial handline (HL) fisheries from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1983 to 1990. (n= sample size)









14

Fig 5 (b). Length frequency distributions for king mackerel length samples collected from commercial handline (HL) fisheries from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1991 to 1997. (n= sample size)



(a) GOM



Fig 5 (c). Length frequency distributions for king mackerel length samples collected from commercial handline (HL) fisheries from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1998 to 2004. (n= sample size)







Fig 5 (d). Length frequency distributions for king mackerel length samples collected from commercial handline (HL) fisheries from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 2005 to 2013. (n= sample size)



(a) GOM

(b) ATL



Fig 6 (a). Length frequency distributions for king mackerel length samples collected from commercial gill net fisheries from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1984 to 1990. (n= sample size)







Fig 6 (b). Length frequency distributions for king mackerel length samples collected from commercial gill net fisheries from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1991 to 1997. (n= sample size)



(a) GOM

(b) ATL

Fig 6 (c). Length frequency distributions for king mackerel length samples collected from commercial gill net fisheries from the Gulf of Mexico (GOM) stock from 1998 to 2013. (n= sample size)





(b) GOM, 2005-2013



Fig 7 (a). Length frequency distributions for king mackerel length samples collected from charter boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1984 to 1990. (n= sample size)







Fig 7 (b). Length frequency distributions for king mackerel length samples collected from charter boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1991 to 1997. (n= sample size)







Fig 7 (c). Length frequency distributions for king mackerel length samples collected from charter boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1998 to 2004. (n= sample size)



(a) GOM

(b) ATL

Fig 7 (d). Length frequency distributions for king mackerel length samples collected from charter boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 2005 to 2013. (n= sample size)



(a) GOM

(b) ATL

n = 754

n = 764

n = 677

n = 667

n = 545

n = 297

n = 229

n = 168

n = 54

Fig 8 (a). Length frequency distributions for king mackerel length samples collected from head boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1984 to 1990. (n= sample size)









Fig 8 (b). Length frequency distributions for king mackerel length samples collected from head boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1991 to 1997. (n= sample size)







(b) ATL

Fig 8 (c). Length frequency distributions for king mackerel length samples collected from head boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1998 to 2004. (n= sample size)









27

Fig 8 (d). Length frequency distributions for king mackerel length samples collected from head boat fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 2005 to 2013. (n= sample size)





(b) ATL



Fig 9 (a). Length frequency distributions for king mackerel length samples collected from private boat and shore fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1984 to 1990. (n= sample size)



(a) GOM



Fig 9 (b). Length frequency distributions for king mackerel length samples collected from private boat and shore fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1991 to 1997. (n= sample size)







30

Fig 9 (c). Length frequency distributions for king mackerel length samples collected from private boat and shore fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1998 to 2004. (n= sample size)







(b) ATL

Fig 9 (d). Length frequency distributions for king mackerel length samples collected from private boat and shore fishery from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 2005 to 2013. (n= sample size)









Fig 10 (a). Length frequency distributions for king mackerel length samples collected from tournament fishing from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1984 to 1990. (n= sample size)







1984

1985

1986

1987

1988

1989

1990

Length

150

n = 1815

n = 379

n = 342

n = 597

n = 539

n = 1488

n = 4585

200

Fig 10 (b). Length frequency distributions for king mackerel length samples collected from tournament fishing from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1991 to 1997. (n= sample size)



(a) GOM

(b) ATL

Fig 10 (c). Length frequency distributions for king mackerel length samples collected from tournament fishing from (a) the Gulf of Mexico (GOM) stock and (b) the Atlantic (ATL) stock from 1998 to 2011. (n= sample size)



(a) GOM

(b) ATL

n = 899

n = 438

n = 560

n = 537

n = 337

n = 980

n = 364

200



Fig 10 (d). Length frequency distributions for king mackerel length samples collected from tournament fishing from the Atlantic (ATL) stock from 2005-2012. (n= sample size)