A Review of Atlantic Spanish mackerel (Scomberomorus maculatus) Age Data, 1986 – 2020, From Various Age-data Sources

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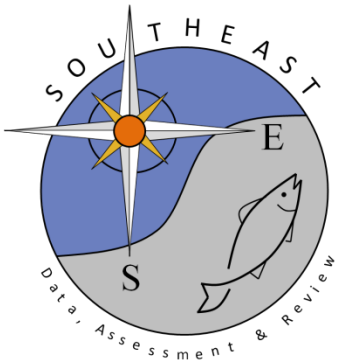

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Introduction

Spanish mackerel, *Scomberomorus maculatus*, range from the western area of the Atlantic Ocean from the Gulf of Maine to the Yucatan Peninsula (Collete et al. 1978). The coasts of Florida make up the bulk of the population which is targeted by both the recreational and commercial fishing sectors throughout this range (Trent and Anthony 1978). Coastal Migratory Pelagic species which includes Spanish mackerel, are managed jointly by the Gulf of Mexico and South Atlantic Fishery Management Councils from the Mexico – Texas border to New York. The objective of this report is to summarize the Atlantic aged samples collected from Virginia through Dade County, Florida and south of Highway 1 in Monroe County, Florida) waters from the years 1986 – 2020 (to date) aged by the Panama City Laboratory of the Southeast Fisheries Science Center, NOAA Fisheries Service (PC Lab), South Carolina Department of Natural Resources (SCDNR), Virginia Marine Resources Commission (VMRC), and Florida Fish and Wildlife Research Institute (FWRI). Information on quality control procedures is also provided.

Methods

Otolith collection and data proofing

Otoliths were collected (1986 – 2020) by federal and state agencies and academic institutions from commercial (CM) and recreational (REC) fisheries and fishery-independent surveys. Fishery dependent samples were collected from several NMFS programs, including the Trip Interview Program (TIP), Southeast Region Headboat Survey (SRHS), and Marine Recreational Fisheries Statistical Survey (MRFSS). Fishery-dependent surveys by state agencies included Florida Wildlife Research Institute Fishery Dependent Monitoring (FWRI FDM), North Carolina Division of Marine Fisheries (NCDMF), Virginia Institute of Marine Science (VIMS), and Virginia Marine Resources Commission (VMRC). Fishery independent samples were received from NCDMF, and South Carolina Department of Natural Resources Coastal Trawl Survey and Reef Fish Survey (SCDNR). The NMFS Panama City Lab did not age samples from SCDNR or VMRC.

Each of the age data sources had separate sampling methods, protocols, and reporting methods unique to that source. The NMFS Panama City Lab (PC Lab) aged data protocols are

outlined in the PC Lab's Procedure Manual for Age, Growth, and Reproduction (AGR)). Initially, beginning in 2000, each species-specific collection was given an annual collection (or tracking) number and all collection-specific data (i.e. source, source number, state, sector, and gear) were entered into a Microsoft® Access database. Validation rules for data entry and user-specific security data for access guidelines were followed to enhance data quality control. The source (or interview) numbers is a source-specific number that allows for cross-referencing of data between the originator's database and the AGR databases. Individual fish data were proofed against original data sheets and corrections were made as needed along with contacting samplers or port agents if required. In 2010 the Panama City lab interfaced with the Biological Samples Database (BSD, Oracle®) for TIP and SRH samples, and in 2017, the AGR Access database was switched to an Oracle database. In 2020 the Panama City lab initiated the use of barcoding samples to streamline the tracking of individual samples, collections, archive storage, and age-data for direct input into both AGR and BSD databases.

Sampling trends

Annual numbers of Spanish mackerel (Mid and South Atlantic) ages provided (1986 - 2020 (as of the date of this report), were summarized by sector (commercial – CM, and recreational – REC) and, for commercial samples, by gear type (hand-line – HL, gillnet – GN, pound net -PN, cast net- CN, long haul - LH, trawl – TRW, seine net -SN, sink net – SK, net – no specific net type, trammel net – TM, or unknown\incomplete data – UNK). Hand-lines included rod and reel gear and trolling methods. The recreational sector included samples from charter boats (CP), headboat (HB), private vessels (PR), shore (SH), but did not include tournament (TRN) samples. Tournament samples were most likely by-catch from king mackerel tournaments or other targeted species events.

Sample numbers were also summarized by Atlantic sub-region where the fish were caught (not necessarily where they were landed nor their stock (Figure 1). Sub-regions, if provided, included south Florida (SF – Monroe County south of Highway 1 only), southeast Florida (SEF – Dade through Broward County), east Florida (EF – Palm Beach through Volusia County), northeast Florida (NEF – Flagler County to the Florida - Georgia border), and the coastal states of Georgia

north to Virginia. Samples from the state of Florida with no sub-region provided were designated as Florida fish (FL). Massachusetts age samples (1990 – 1992, n=83) were not included with this report, but were included as a sub-tab in the main data file. Upon further discussion with Jennifer Potts (NMFS Beaufort, NC Laboratory) and Rob Cheshire (NMFS Miami, FL. Laboratory), the agreement was made that samples from Massachusetts are considered as North Atlantic region managed fish (stock) and should not be included with the supplied Mid or South Atlantic age data.

Age determination and estimates of precision

All ages were derived from sagittal otoliths. Otoliths from males < 45 cm FL and females < 55 cm FL were read whole; larger fish were aged using sectioned otoliths. Annuli of whole and sectioned otoliths were identified using the methods of Fable et al. (1987). All Spanish mackerel aged by the Panama City lab after SEDAR 28 were aged by C. Palmer. Three indices of precision - average percent error (APE), coefficient of variation (CV), and precision (D) – were calculated from whole otolith ages of 50 fish by C. Palmer and 50 sectioned otolith ages from 2015 by C. Palmer to check for consistency and precision. The goal was to achieve and APE of < 5.0%. See Palmer et al. (2007) for further discussion on ageing precision.

Calendar ages, based on calendar year, were calculated using the annulus count, edge-type, and capture date. Typically, annuli are deposited in the spring (Fable et al. 1987), and advancing ages is often necessary for fish captured in the early part of the year to direct fish into the correct cohort (DeVries and Grimes 1997). Protocols for advancing ages were the same as used for the similarly related king mackerel: 1) fish sampled January – May with marginal increments estimated to be > 35% of the previous increment were advanced one year; and 2) otoliths sampled June – July 15th with > 2 annuli and a marginal increment > 35% of the previous increment were advanced one year. Otoliths with 2 or fewer annuli during the same time were advanced one year only if the marginal increment was > 70% of the previous increment. This different standard for younger fish was necessary because their overall annual growth is much greater and their growth rate is faster than older fish, and it is a normal occurance for them to

already have relatively large marginal increments as early as June. Ages were not advanced for fish sampled July 16th through the end of the calendar year (DeVries and Grimes 1997).

Otoliths with no annuli present (age-0) were treated separately for calendar age calculations, because for these samples an edge-code was not recorded. In general, each annulus is completely formed by mid-July. Fish with no annuli were captured in most months of the year. The month of peak spawning of Spanish mackerel is June, though the spawning season can start in April and continue through September. For fish caught before biological birthdate of June 1, the fractional ages, would be negative numbers. A plot of the lengths by day of year caught of the fish with no annuli revealed a natural progression of size at age, and that those fish caught before June 1 were of such a size that we assumed they would be one-year old fish that calendar year (Figure 2a). Thus, we advance all fish with zero annuli by one year if they were caught before June 1. An additional plot of length at day of capture of the fish calendar age of 1 year showed that the size of the zero-annulus fish prior to June 1 fall within a similar size range (Figure 2b). This information further confirms the assumption that the fish with no annulus in the SEDAR 78 data set caught before June 1 would be one-year old in that calendar year.

Results and Discussion

Sampling trends

A total of 32,348 (1986 – 2020) Spanish mackerel ages from Panama City Laboratory of the Southeast Fisheries Science Center, NOAA Fisheries Service (PC Lab), South Carolina Department of Natural Resources (SCDNR), Virginia Marine Resources Commission (VMRC), and Florida Fish and Wildlife Research Institute (FWRI) were compiled for the age data set provide for SEDAR 78 (Table 1). Of those ages, 58% were from the commercial sector, 24% from the recreational sector (CP, HB, PR, and SH combined), 12% scientific surveys, 3% from tournaments, and 2% from unknown sectors (Table 2). The Trip Interview Program was the largest source of samples (36%), followed by the North Carolina Division of Marine Fisheries (34%), and Virginia Marine Resources Commission (16%) (Table 3). The majority of the Atlantic aged samples came from North Carolina (37%), East Florida (Palm Beach through Volusia County, 35%), and Virginia (17%) (Table 4).

The bulk of commercial samples (59%) came from east Florida, followed by Virginia (29%), and North Carolina (14%) (Table 5). Recreational samples mainly came from North Carolina (89%) followed by Virginia (5%) (Table 5). Commercial Spanish mackerel age samples primarily came from gill-nets (42%), pound-nets (23%), and hook-and-line gear (17%) (Table 6).

Age determination and rates of precision

Reader comparison (C. Palmer vs. C Palmer) for whole and sectioned otoliths resulted in an APE of 3.07%, CV of 4.38%, and a corresponding D of 3.10%, indicating low reader error along with high precision.

Age and length composition

Spanish mackerel collected during 1986 – 2020 ranged in age from 0 to 11 yr with the majority between 0 and 4 yr (Figure 3). Females and males both ranged in age from 0 to 11 yr with ninety two percent of aged females and males ages 0 to 4 yr (Figure 3). Mean sizes at age were larger for females in all ages (Figure 4,Table 7). The size ranges of the commercial and recreational samples were similar although the mode of the commercial samples was ~50mm larger than recreationally caught fish (390-410 vs 240-360 mm FL) (Figure 5). Mean size at age were similar up to age 3 yr and fish > 3 yr were larger for recreationally caught fish (Figure 6). Aged fish from the recreational fishery had similar size ranges per mode with the charter boat fishery contributing the bulk of those samples followed by tournament caught fish (Figure 7). Tournament caught samples could have either been incidental catches or targeted fish along with headboat caught fish as well. Tournament samples did have a slightly larger size than charter-boat aged fish (350-370 vs 340-360 mm FL) while the numbers of aged fish from the private and headboat fishery were too low to designate a confident size range (Figure 7).

Changes to data submitted for SEDAR28

While compiling data for SEDAR78, all contributors sent not just age data since 2011, but they included data submitted for the previous SEDAR, #28. SCDNR provided age data from the commercial fishery between 1986 and 1991 for SEDAR28 for gillnet, hook and line and trawl gears. While verifying data, SCDNR was not able to confirm the sampling methodology or the

fishery of those samples, so they were included in the submission for SEDAR78, but as fishery-independent collected samples or unknown fishery. These data would not be used for commercial age comps in SEDARA78. Another change was made to the data previously submitted by VMRC for SEDAR28. Their staff was able to label each record with the fishery source and gear for samples from collected in 2002 – 2011, which were previously unknown. These samples potentially can be used for fishery age comps.

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Table 1. Annual numbers (1986 - 2020) of aged Spanish mackerel by data provider. PC Lab - NMFS Panama City Laboratory, VMRC - Virginia Marine Resources Commission, SCDNR - South Carolina Department of Natural Resources, FWRI Florida Wildlife Research Institute.

Year	PC Lab	VMRC	SCDNR	FWRI	Total
1986			38		38
1987			23		23
1988	177		162		339
1989	208		155		363
1990	554		206		760
1991	609		28		637
1992	740				740
1993	463				463
1994	204				204
1995	336				336
1996	564				564
1997	683				683
1998	749				749
1999	732				732
2000	1,030				1,030
2001	800				800
2002	730	856			1,586
2003	646	381			1,027
2004	794	425			1,219
2005	699	347			1,046
2006	847	291			1,138
2007	667	250			917
2008	994	242			1,236
2009	1,033	181			1,214
2010	737	225			962
2011	919	232	272		1,423
2012	1,076	184	263		1,523
2013	726	148	252		1,126
2014	1,038	236	377		1,651
2015	650	231	235	2	1,118
2016	945	220	438		1,603
2017	600	234	372	14	1,220
2018	1,000	201	279	22	1,502
2019	880	233	342	37	1,492
2020	674	200		10	884
Total	23,504	5,317	3,442	85	32,348
% of Total	73%	16%	11%	0%	100%

Table 2. Annual numbers (1986 - 2020) of aged Spanish mackerel by sector. CM - commercial, REC - recreational, SS - scientific survey, TRN - tournament, UNK - incomplete data.

Year	COM	REC	SS	TRN	UNK	Total
1986			37		1	38
1987			23			23
1988	1	117	53	62	106	339
1989	2	56	24	171	110	363
1990	162	309	23	110	156	760
1991	231	192		211	3	637
1992	487	198		42	13	740
1993	235	104	103	21		463
1994	32	171			1	204
1995	219	70	47			336
1996	486	78				564
1997	367	316				683
1998	527	219			3	749
1999	628	89	2	5	8	732
2000	796	130			104	1,030
2001	747	49	4			800
2002	1,300	204	81		1	1,586
2003	694	235	12	86		1,027
2004	969	239	9	2		1,219
2005	757	208	21		60	1,046
2006	859	233	22		24	1,138
2007	697	176	16	1	27	917
2008	911	181	119	25		1,236
2009	891	64	254	5		1,214
2010	613	296	29	19	5	962
2011	788	284	278	73		1,423
2012	747	429	268	79		1,523
2013	479	337	271	39		1,126
2014	755	447	391	58		1,651
2015	483	336	240	59		1,118
2016	584	491	469	59		1,603
2017	450	353	417			1,220
2018	735	409	357		1	1,502
2019	635	470	385		2	1,492
2020	494	302	69		19	884
Total	18,761	7,792	4,024	1,127	644	32,348
% of Total	58%	24%	12%	3%	2%	100%

Table 3. Annual numbers (1986 - 2020) of aged Spanish mackerel by source. TIP - Trip Interview Program, NCDMF - North Carolina Division of Marine Fisheries, VMRC - Virginia Marine Resources Commission, SCDNR - South Carolina Department of Natural Resources, VIMS - Virginia Institute of Marines Science, SRHS - Southeast Region Headboat Survey, FWRI - Florida Fish and Wildlife Research Institute, MRFSS - Marine Recreational Statistical Survey, ECFIN - Gulf States Commission's Statistical Survey, UNK - incomplete data.

Year	TIP	NCDMF	VMRC	SCDNR	VIMS	SRHS	FWRI	MRFFS	RECFIN	UNK	Total
1986				38							38
1987				23							23
1988				162						177	339
1989				155						208	363
1990	17	379		206						158	760
1991	289	306		28						14	637
1992	280	447								13	740
1993	195	268									463
1994	22	182									204
1995	165	171									336
1996	450	114									564
1997	280	403									683
1998	331	418									749
1999	459	273									732
2000	468	458			104						1,030
2001	315	485									800
2002	359	333	856					38			1,586
2003	316	318	381					12			1,027
2004	507	280	425			3		3	1		1,219
2005	402	285	347					5	7		1,046
2006	566	277	291			4					1,138
2007	373	294	250								917
2008	671	322	242					1			1,236
2009	732	299	181			2					1,214
2010	343	394	225								962
2011	521	397	232	272					1		1,423
2012	521	549	184	263		6					1,523
2013	348	370	148	252		8					1,126
2014	498	510	236	377		19			11		1,651
2015	240	398	231	235		12	2				1,118
2016	384	556	220	438		5					1,603
2017	206	392	234	372		2	14				1,220
2018	548	440	201	279		12	22				1,502
2019	463	403	233	342		14	37				1,492
2020	363	311	200				10				884
Total	11,632	11,032	5,317	3,442	104	87	85	59	20	570	32,348
% of Total	36%	34%	16%	11%	<1%	<1%	<1%	<1%	<1%	2%	100%

Table 4. Annual numbers (1986 - 2020) of aged Spanish mackerel by state. NC- North Carolina, EF - East Florida, VA - Virginia, GA -Georgia, SC - South Carolina, FL (no sub region), SEF - Southeast Florida, SF - South Florida, NEF - Northeast Florida, UNK - incomplete data.

Year	NC	EF	VA	GA	SC	FL	SEF	SF	NEF	UNK	Total
1986	9			8	19	2					38
1987	8			14	1						23
1988	154	6		48	84	46				1	339
1989	61	60		175	56	4				7	363
1990	425	173		106	53					3	760
1991	328	88		210	11						637
1992	526	85		36	93						740
1993	268	164			31						463
1994	182	22									204
1995	171	165									336
1996	114	450									564
1997	403	280									683
1998	418	331									749
1999	273	459									732
2000	458	468	104								1,030
2001	485	315									800
2002	333	395	856						2		1,586
2003	318	328	381								1,027
2004	280	512	425				2				1,219
2005	285	413	347				1				1,046
2006	277	491	291				4	75			1,138
2007	294	368	250				4	1			917
2008	322	672	242								1,236
2009	299	732	181				1	1			1,214
2010	394	342	225					1			962
2011	473	521	232	54	63	79		1			1,423
2012	590	521	184	105	77	40	1	5			1,523
2013	433	321	148	64	98	27	32	3			1,126
2014	581	456	236	106	103	98	55	11	5		1,651
2015	440	239	231	64	78	53	11	1	1		1,118
2016	610	383	220	124	78	182	5	1			1,603
2017	451	213	234	135	117	61			9		1,220
2018	524	554	201	69	88	46	15	4	1		1,502
2019	499	460	233	85	102	73	30	10			1,492
2020	311	366	200					7			884
Total	11,997	11,353	5,421	1,403	1,152	711	161	121	18	11	32,348
% of Total	37%	35%	17%	4%	4%	2%	<1%	<1%	<1%	<1%	100%

Table 5. Annual numbers (1988 - 2020) of aged Spanish mackerel from commerical and recreational fisheries by state. EF - East Florida, VA - Virginia, NC - North Carolina, SEF - Southeast Florida, SF - South Florida, SC - South Carolina, GA- Georgia, UNK - incomplete data.

	Commercial								Recreational									
Year	EF	VA	NC	SEF	SF	SC	UNK	Total	NC	VA	SC	EF	SEF	SF	GA	NEF	Total	Grand Total
1988							1	1	83		28	6					117	118
1989						2		2	4		52						56	58
1990	41		121					162	253		22				34		309	471
1991	77		154					231	173		8	11					192	423
1992	85		349			53		487	162		36						198	685
1993	164		71					235	75		29						104	339
1994	22		10					32	171								171	203
1995	163		56					219	68			2					70	289
1996	449		37					486	77			1					78	564
1997	280		87					367	316								316	683
1998	331		196					527	219								219	746
1999	459		169					628	89								89	717
2000	468		328					796	130								130	926
2001	314		433					747	49								49	796
2002	354	856	90					1,300	162			40				2	204	1,504
2003	311	381	2					694	218			17					235	929
2004	503	425	40	1				969	229			9	1				239	1,208
2005	401	347	9					757	195			12	1				208	965
2006	491	291	2		75			859	229				4				233	1,092
2007	368	250	75	4				697	175					1			176	873
2008	671	240						911	178	2		1					181	1,092
2009	732	155	4					891	36	26			1	1			64	955
2010	342	205	66					613	275	20				1			296	909
2011	521	223	44					788	274	9				1			284	1,072
2012	521	166	60					747	405	18			1	5			429	1,176
2013	321	100	31	26	1			479	281	48			6	2			337	816
2014	455	225	33	42				755	406	11		1	13	11		5	447	1,202
2015	238	194	51					483	285	37		1	11	1		1	336	819
2016	383	197	3	1				584	463	23			4	1			491	1,075
2017	206	212	32					450	315	22		7				9	353	803
2018	548	183	4					735	363	18	2	6	15	4		1	409	1,144
2019	453	167	5	10				635	361	66	6	7	20	10			470	1,105
2020	363	131						494	223	69		3		7			302	796
Total	11,035	4,948	2,562	84	76	55	1	18,761	6,942	369	183	124	77	45	34	18	7,792	26,553
% of Total	59%	26%	14%	<1%	<1%	<1%	<1%	100%	89%	5%	2%	2%	<1%	<1%	<1%	1%	100%	

Table 6. Annual numbers (1988 - 2020) of commerical aged Spanish mackerel by gear type. GN - gill net, PN - pound net, HL - hand-lines, CN - cast net, LH - long haul, TRW - trawl, SN - seine net, SK - sink net, Net - unspeficiet net type, TM - trammel net, UNK - incomplete data.

Year	GN	PN	HL	CN	LH	TRW	SN	SK	Net	TM	UNK	Total
1988											1	1
1989						2						2
1990	80	6	41			24	1				10	162
1991	175						27		28		1	231
1992	190	28	81		36	109					43	487
1993	150				27						58	235
1994	10		6								16	32
1995	167	20	25		7							219
1996	417		35		34							486
1997	246	4	34	34	18	31						367
1998	363	50	31		81	2						527
1999	447	23	120				4	33		1		628
2000	588		147	3	54	4						796
2001	315	60	242	110	20							747
2002	365	773	61			12	89					1,300
2003	365	329										694
2004	551	400	2			16						969
2005	256	341	13	147								757
2006	358	286		211	2		2					859
2007	234	226	177	50	7		3					697
2008	288	110	187	265		57					4	911
2009	348	98	105	331			8				1	891
2010	287	187		139								613
2011	389	210	94	95								788
2012	208	166	64	309								747
2013	201	42	231	1			4					479
2014	203	172	342	30							8	755
2015	205	186	33	59								483
2016	287	175	90	29			3					584
2017	136	193	84	36			1					450
2018	31	111	325	230			38					735
2019	30	134	345	123			3					635
2020	68	78	244	104								494
Total	7,958	4,408	3,159	2,306	286	257	183	33	28	1	142	18,761
% of Total	42%	23%	17%	12%	2%	1%	1%	<1%	<1%	<1%	1%	100%

Table 7. Mean observed fork lenth (mm) at age in mm and standard error for female and male Spanish mackerel (1986 - 2020) ages.

Females				Males			
Age	N	Mean	Std Error	Age	N	Mean	Std Error
0	1,561	312.8	53.77	0	1,254	298.7	54.84
1	7,091	366.9	46.30	1	5,001	341.8	37.15
2	3,566	436.4	54.84	2	2,389	400.3	42.94
3	2,268	480.8	63.06	3	1,532	434.6	53.79
4	1,535	521.8	70.90	4	994	466.3	63.25
5	810	551.0	70.05	5	485	489.7	65.79
6	352	575.5	72.28	6	228	511.9	68.46
7	165	598.7	72.13	7	110	535.3	64.18
8	60	627.1	62.90	8	41	547.9	51.77
9	22	634.0	41.13	9	19	530.1	45.63
10	19	662.7	79.98	10	8	576.2	41.80
11	3	738.0	19.29	11	1	555.0	0.00

Figure 1. Atlantic Spanish mackerel age sampled regions (1986 – 2020). FL – Florida, SF – south Florida, EF – east Florida, NEF – Northeast Florida, GA – Georgia, SC – South Carolina, NC – North Carolina, VA – Virginia, MA – Massachusetts (for reference).

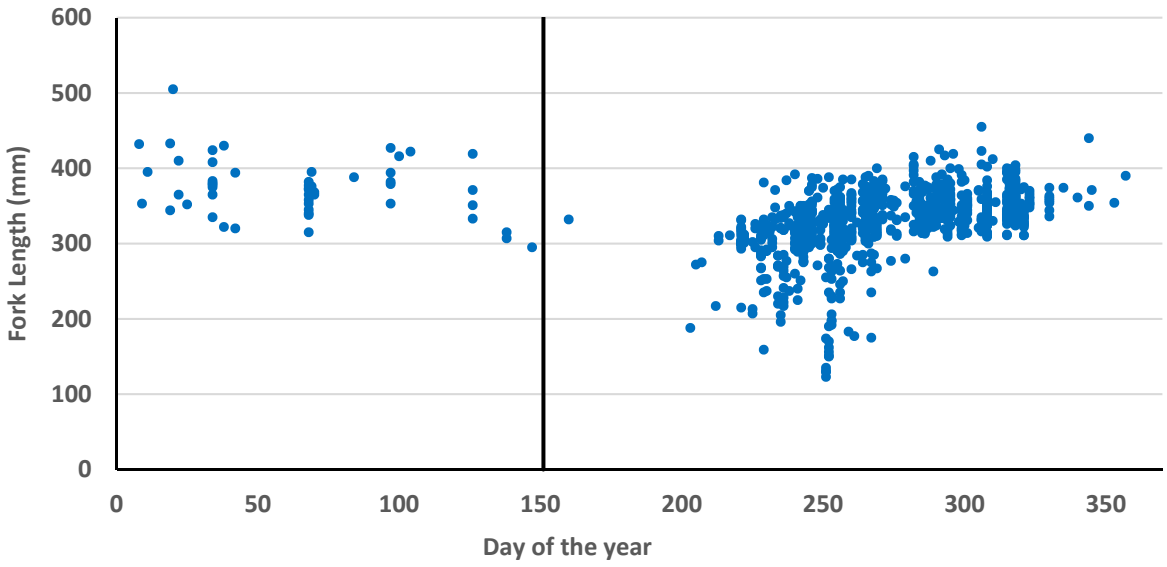

Figure 2a. Fork length at day of year caught of Spanish Mackerel with no annuli. The vertical line is positioned at day = 151 (June 1) the start of peak spawning and equivalent to the biological birthdate.

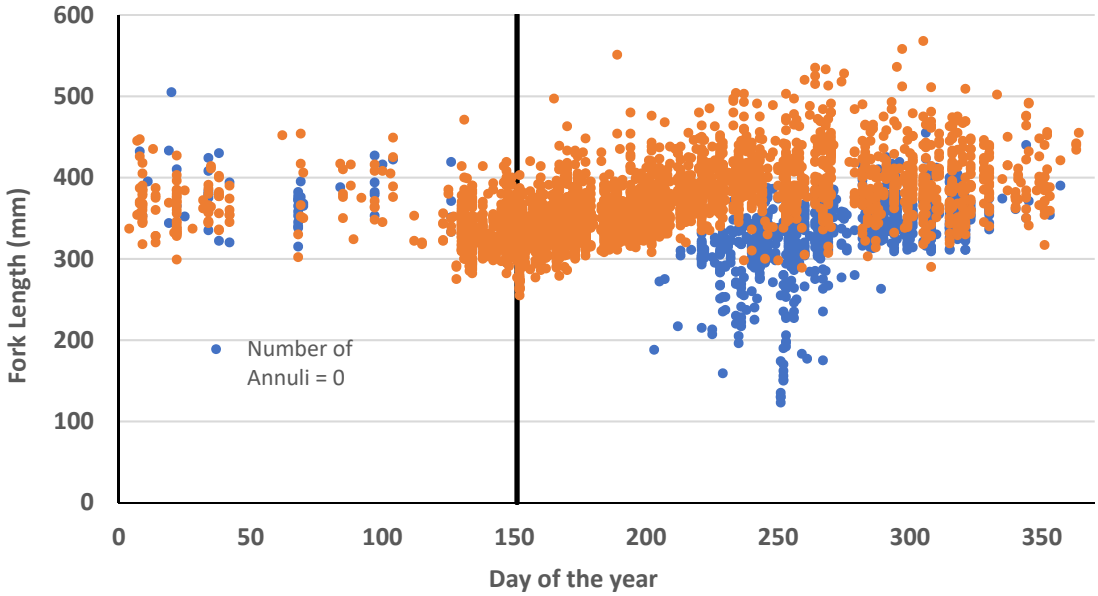

Figure 2b. Fork length at day of year caught of Spanish Mackerel with no annuli and Calendar Age = 1 year. The vertical line is positioned at day = 151 (June 1) the start of peak spawning and equivalent to the biological birthdate.

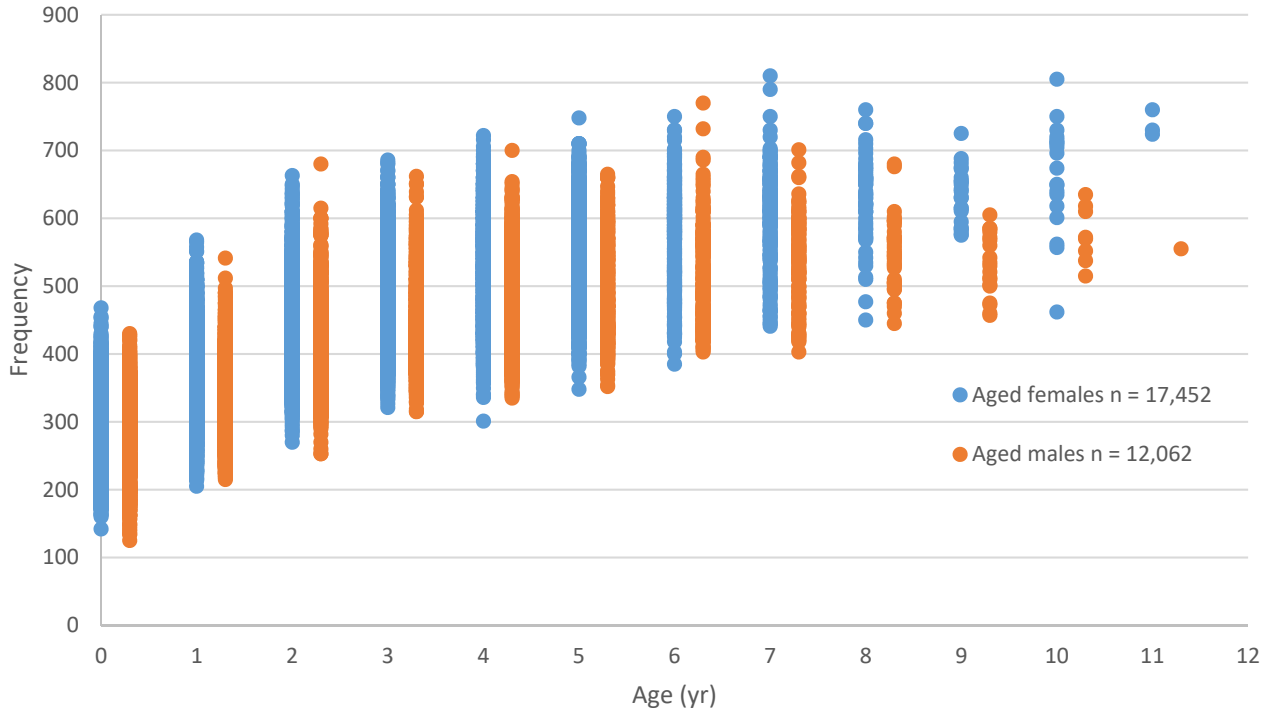

Figure 3. Sizes at age of female and male (1986 - 2020) Spanish mackerel.

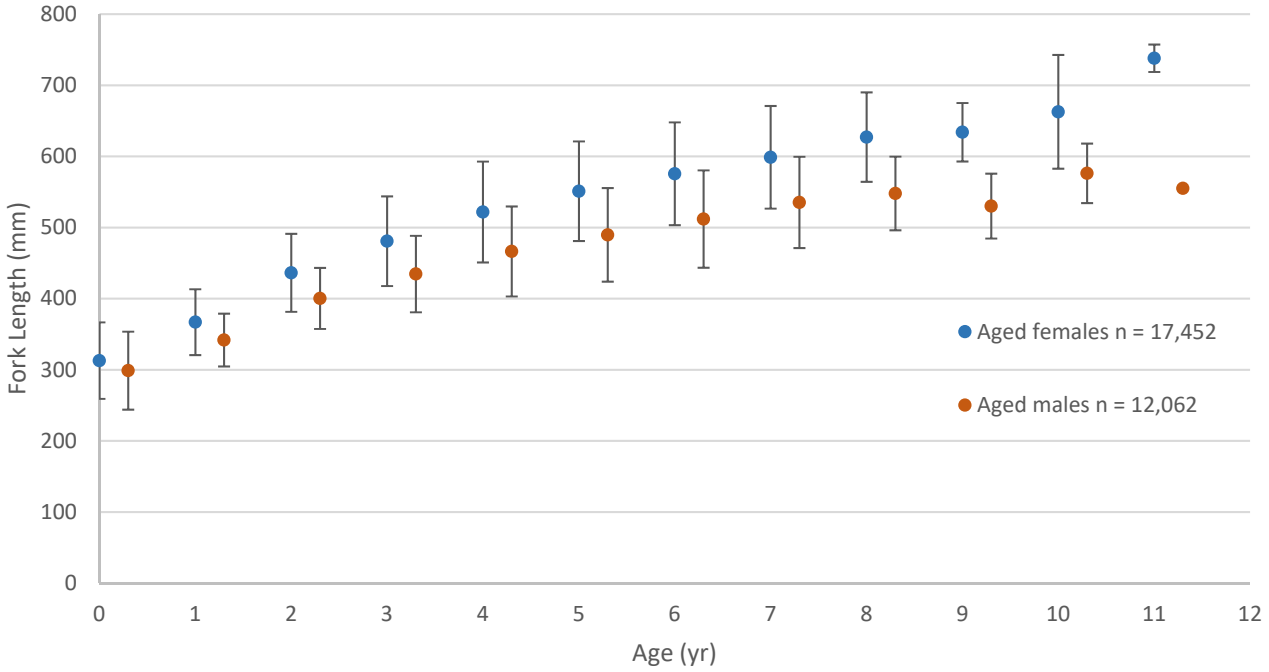

Figure 4. Mean size at age of female and male (1986 - 2020) Spanish mackerel. Error bars are +/- 1 standard deviation.

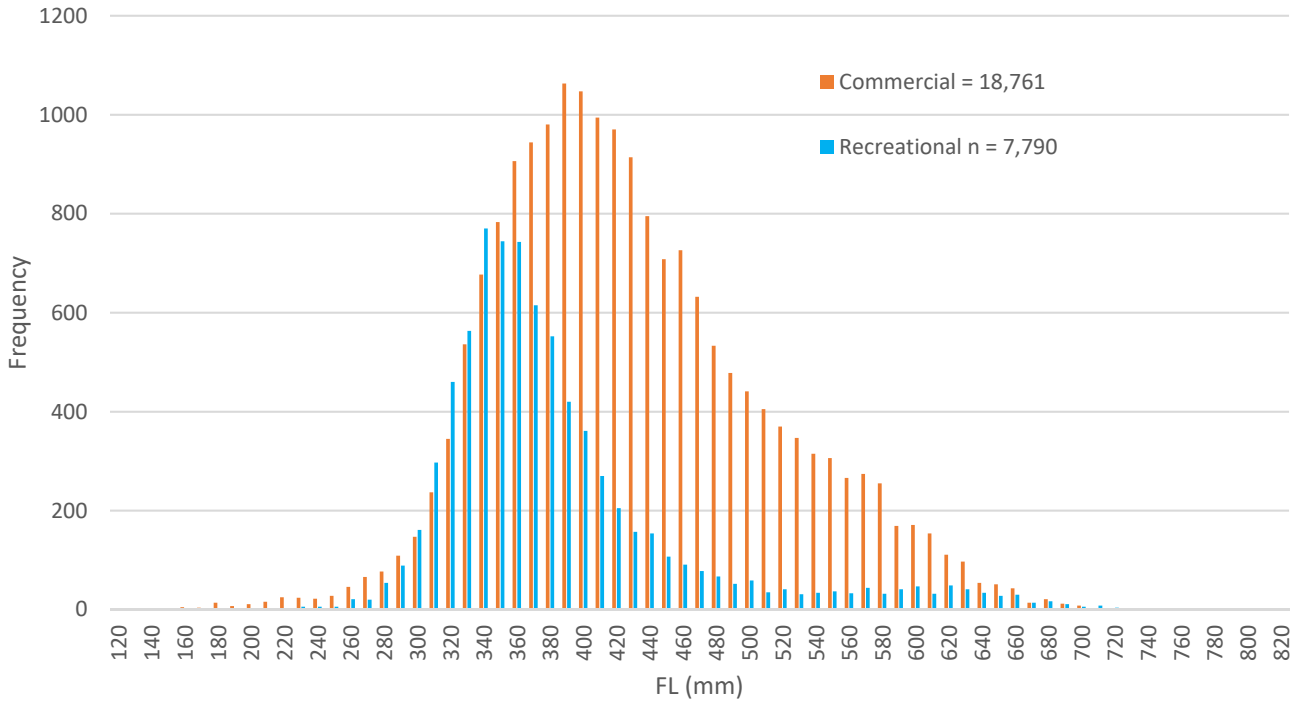

Figure 5. Length frequency of commercial and recreational aged (1986 - 2020) Spanish mackerel.

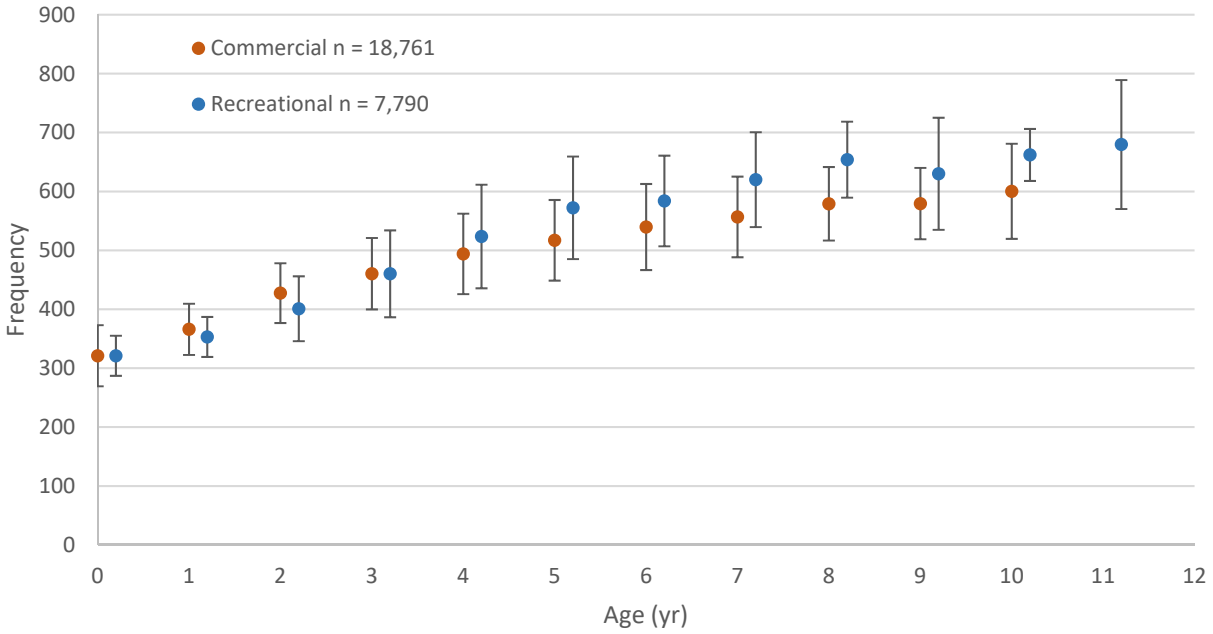

Figure 6. Mean size at age of commercial and recreational (1986 -2020) aged Spanish mackerel. Error bars are +/- 1 standard deviation

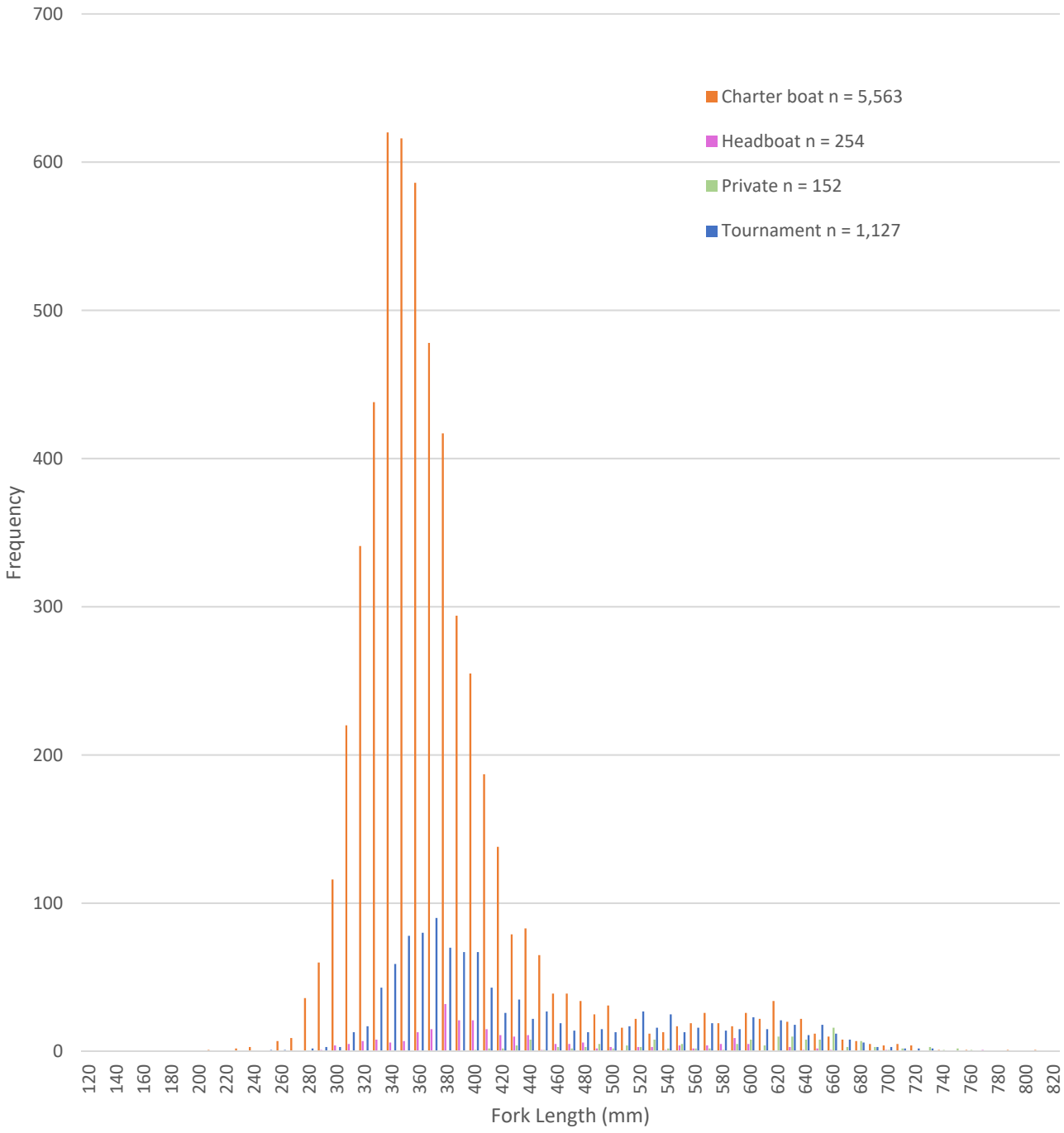

Figure 7. Length frequency of recreational (1986 - 2020) aged Spanish mackerel from charter boat, head boat, private, and tournament caught fish.