A review of Spanish mackerel (*Scomberomorus maculatus)* age data, 1987-2007, Atlantic collections only, from the Panama City Laboratory, Southeast Fisheries Science Center, NOAA Fisheries Service

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Contribution 08-08

May, 2008

Introduction

Spanish mackerel, *Scomberomorus maculatus*, are found in the western Atlantic Ocean from the Gulf of Maine to the Yucatan Peninsula (Collette et al. 1978). The majority of the population resides in Florida waters and they are targeted by both the recreational and commercial fishing sectors throughout their range (Trent and Anthony 1978). The fishery is managed under the Coastal Migratory Pelagic Resources Fishery Management Plan which encompasses both the Atlantic Ocean and Gulf of Mexico stocks. The primary objective of this report is to give an overview of the temporal and spatial distributions, as well as distributions by fishery and gear, of Spanish mackerel age samples collected in Atlantic waters (Massachusetts through Monroe County, Florida) from the years 1987 through 2007 aged by the Panama City Laboratory of the Southeast Fisheries Science Center, NOAA Fisheries Service. Information on quality control procedures is also provided.

Methods

Otolith collection and data proofing

Otoliths were collected 1987 – 2007 by federal and state agencies and academic institutions from both commercial (CM) and recreational (REC) fisheries. Fishery dependent samples were obtained from several NMFS programs, including the Trip Interview Program (TIP), Beaufort Lab Head Boat Survey (HB), Marine Fisheries Recreational Statistical Survey (MRFSS), Gulf States Marine Fisheries Commission's Recreational Fisheries Independent Network (RECFIN), as well as North Carolina Department of Natural Resources (NCDNR), and Virginia Institute of Marine Science (VIMS).

Each of the data collection sources had separate but similar sampling procedures, data protocols, and reporting methods. Data quality control guidelines as described by the Panama City Lab's Procedure Manual for Age, Growth, and Reproduction (AGR)

(NMFS 2004) were used to interpret source-specific datasheets. First, beginning in 2000, each species specific collection was assigned 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 for data accessibility guidelines were followed to enhance data quality control. The source (or interview) number is a source-specific number that permits cross-referencing of data between the original and the Panama City annual AGR databases. Next, all individual fish data were proofed against the original data sheets. Corrections were made to the AGR database as needed and any specific data issues were resolved by personal contact with port agents or samplers.

To insure uniform standards of quality control, all 1987 – 2007 data were proofed against original data sheets (archived at the Panama City lab). TIP specific data were proofed using original TIP data sheets or by accessing online TIP files.

Sampling trends

Annual numbers of otolith samples received and aged at the Panama City lab during 1987 – 2007 from Atlantic waters of the southeastern U.S. were summarized by sector (commercial – CM, recreational – REC, and tournament –TRN) and by commercial gear type (hand-line – HL, gillnet – GN, cast net – CN, and other). Hand-lines included rod and reel gear or methods such as trolling, sight casting, etc. Other gear types included fly nets, long haul seines, trawls, seines, sink nets, trammel nets, and pound nets. The recreational sector included samples from charter boats (CP), head boats (HB), and private vessels (PR), but excluded tournament samples. Data that was not available or could not be verified was classified as Unknown.

Data were summarized by sub-region which included Massachusetts – MA, Virginia – VA, North Carolina – NC, South Carolina – SC, Georgia – GA, northeast Florida – NEF (Flagler County to the Florida-Georgia border), east Florida – EF (Palm Beach through Volusia County), southeast Florida – SEF (Dade through Broward County), and south Florida – SF (Monroe County only).

Age determination and estimates of precision

All ages were derived from sagittal otoliths (Fable et al. 1978). Otoliths from males < 45 cm FL and females < 55 cm FL were read whole, while larger specimens from both sexes were sectioned. Annuli of whole and sectioned otoliths were identified following the methods of Fable et al. (1987) and those used for king mackerel (DeVries and Grimes 1997). All Spanish mackerel collected prior to the 2001-02 fishing season were aged by Reader 1 (D. DeVries). Thereafter, Reader 2 (C. Palmer) became the primary ager. About 22% (721 of 3224) of all otoliths from the 2001-02 and 2002-03 fishing seasons were read by both Readers 1 and 2, and three indices of precision - average percent error (APE), coefficient of variation (CV), and precision (D) - were calculated from those data to check for consistency and drifts in precision between readers. The goal was to achieve an APE of < 5.0%. See Palmer et al. (2007) for further discussion on ageing precision. To check for drift in otolith interpretation over time between Readers 1 and 2, 19% (100 of 527) of whole otoliths from 2006 were read by both readers; APE, CV, and D were then calculated and the results compared with those from the 2001-02 and 2002-03 data. Reader 3 (C. Fioramonti) became the primary reader for all sectioned samples beginning with the 2005-06 collections. Roughly 12% (55 of 448) of sectioned samples from the 2005-06 fishing season through 2007 were read by both Readers 2 and 3, and those data were also analyzed to assure acceptable levels of precision.

Annual ages, based on calendar year, were calculated using the annulus count, edge-type and capture date. Annulus formation typically occurs in the spring (Fable et al. 1987), and advancement of ages is often necessary for fish captured that time of year in order to assign fish to the correct cohort (DeVries and Grimes 1997). The protocol for advancing ages was the same as that used for the closely related king mackerel: 1) fish sampled January – May with a marginal increment estimated to be > 35% of the previous increment were advanced one year; and 2) fish sampled June – July 15th with > 2 annuli and a marginal increment > 35% of the previous increment were advanced one year, while those with 2 or fewer annuli sampled during the same time were advanced one year only if the marginal increment was > 70% of the previous one. This distinction was

made because younger fish grow more and faster than older fish, and it is not uncommon for them to already have relatively large marginal increments as early as June. Ages were not advanced for fish sampled July 16th – December (DeVries and Grimes 1997).

Results and Discussion

Sampling trends

A total of 13,405 Spanish mackerel collected from 1987 through 2007 from the Atlantic have been aged by the Panama City Laboratory and made available for SEDAR 17. Of all the aged samples, 62% were from the commercial sector, 26% from the recreational sector (CP, HB, and PR combined and excluding tournaments), and 6% from tournaments (Table 1). In addition, 3% of the aged samples were from scientific surveys and 3% were from unknown sectors. North Carolina (45%) and east Florida (41%) were the main sources of aged samples from the Atlantic region (Table 2).

East Florida (62%) was the main contributor of commercial samples followed by North Carolina (27%) and Virginia (10%) (Table 3). The majority of all Atlantic recreational samples came from North Carolina (91%) followed by South Carolina (5%) and east Florida (3%) (Table 4). Tournament samples accounted for roughly 6% (737 of 13,405) of all aged samples (Table 5). Georgia (71%) accounted for the bulk of tournament aged fish followed by North Carolina (20%) and South Carolina (9%).

Of all commercial Spanish mackerel age samples from the Atlantic, 60% were collected from gillnet fisheries followed by hand-lines (12%) (Table 6). For another 12% the gear type was unknown. The majority of the unknowns were from the Virginia Institute of Marine Science (VIMS) in 2002. Other gear types (9%) were fly nets, seine nets, pound nets, sink nets, trammel nets, and trawl nets.

The Trip Interview Program (TIP) and the North Carolina Department of Marine Resources each accounted for about 43% of the aged samples and the Virginia Institute of Marine Science contributed 7% (Table 7).

Age determination and estimates of precision

Reader comparison results (Table 8) showed high precision between Readers 1 and 2 for the 2001-02 and the 2002-03 data years (fishing seasons). An APE of 2.43%, CV of 2.90%, and a resulting 1.71% index of precision (D) reflect low reader error. Analysis of the whole otolith comparison between Readers 1 and 2 from data year 2006 yielded an APE of 1.48%, CV of 2.09%, and a corresponding D of 1.04%, indicating low reader error and little, if any, drift in otolith interpretation over time. Precision levels were also high between Readers 2 and Reader 3 for sectioned ages from the 2005-2007 data, with an APE of 3.87%, CV of 5.48%, and a resultant D of 2.74% (Table 8).

Age and length composition

Atlantic Spanish mackerel collected during 1987-2007 and aged by the NMFS Panama City Lab ranged from 0 to 11 yr, with 91% (12,191 of 13,405) between ages 0 and 4 yr (Figure 1). Both females (N = 7,797) and males (N = 5,211) ranged from age 0 to 11 yr (Figure 2). Fish which were not sexed (sex = unknown) because they were gutted or had unidentifiable gonads (N = 391) ranged in age from 0 to 4 yr.

The size ranges of the commercial (N = 8,380) and recreational (N = 3,479) age samples were similar (~250 – 700 mm / 9.8 – 27.6 in), as were the modes of the distributions (400 mm / 15.75 in); however, the proportion of larger fish (>400 mm FL) was much higher in the commercial samples (Figure 3). Recreationally-caught females above age 3 averaged larger at age than those from commercial catches, possibly reflecting differences in selectivity and/or spatial distribution of the samples (Tables 9 and 10, Figure 4). Mean size at age in males was consistently smaller in recreational than commercial samples for ages 0 – 6, and above that age small sample sizes made comparisons questionable at best (Tables 11 and 12, Figure 5). As with females, these size at age differences probably reflect differences in selectivity and/or spatial distribution of the samples. Lengths at age by sex for all sectors combined are shown in Figure 6.

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Table 1. Annual numbers of Spanish mackerel, 1987-2007, by source, aged by NMFS Panama City. CM = commercial, CP = charter boat, PR = private, TRN = tournament, SS = scientific survey, HB = head boat, UNK = unknown.

Year	CM	CP	PR	TRN	SS	HB	UNK	Total
1987		27	97	26			108	258
1988		6	109	62			7	184
1989			34	171			3	208
1990	152	66	205	110			42	575
1991	203	22	170	211	40		3	649
1992	513	182	16	42	37		14	804
1993	235	13	91	21	103			463
1994	32	171					1	204
1995	219	70			47			336
1996	486	73	5					564
1997	341	228	88				26	683
1998	527	165	23			31	3	749
1999	628	40	49	5	2		8	732
2000	796	76	54				104	1,030
2001	747	38	11		4			800
2002	1,297	161	43		81		1	1583
2003	313	233	2	86	12			646
2004	544	97	7	2	9	135		794
2005	413	194	9		4	1	77	698
2006	498	240	11		24	4		777
2007	441	182		2	43			668
Total	8,386	2,284	1,024	738	406	171	397	13,405
% of Total	62.55	17.04	7.64	5.51	3.03	1.28	2.96	100

Table 2. Annual numbers of Spanish mackerel from the Atlantic, 1987-2007, by sub-region, aged by NMFS Panama City. NEF = northeast Florida, EF = east Florida, SEF = southeast Florida, SF = south Florida.

Year	MA	VA	NC	SC	GA	NEF	EF	SEF	SF	Total
1987			67	28	59		104			258
1988			91	62	25		6			184
1989			7	30	171					208
1990	21		412	28	72		42			575
1991	40		328	11	210		60			649
1992	37		553	93	36		85			804
1993			268	31			164			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		104	458				468			1,030
2001			485				315			800
2002		853	333			2	395			1,583
2003			318				328			646
2004			280				512	2		794
2005			285				413			698
2006			277				496	4		777
2007			295				368	4	1	668
Total	98	957	6,018	283	573	2	5,463	10	1	13,405
% of Total	0.73	7.14	44.89	2.11	4.27	0.01	40.75	0.07	0.01	100

Table 3. Annual numbers of Spanish mackerel from Atlantic commercial samples, 1990-2007, by sub-region, aged by NMFS Panama City. EF = east Florida, SEF = southeast Florida, SF = south Florida

Year	VA	NC	SC	EF	SEF	SF	Total
1990		111		41			152
1991		154		49			203
1992		375	53	85			513
1993		71		164			235
1994		10		22			32
1995		56		163			219
1996		37		449			486
1997		76		265			341
1998		196		331			527
1999		169		459			628
2000		328		468			796
2001		433		314			747
2002	853	90		354			1,297
2003		2		311			313
2004		40		503	1		544
2005		13		400			413
2006		2		492			494
2007		68		367	4	1	440
Total	853	2,231	53	5,237	5	1	8,385
% of Total	10.18	26.62	0.63	62.49	0.06	0.01	100

Table 4. Annual numbers of Spanish mackerel from Atlantic recreational samples (excluding tournaments), 1987-2007, aged by the NMFS Panama City, by sub-region. NEF = northeast Florida, EF = east Florida, SEF = southeast Florida.

Year	EF	GA	NC	NEF	SC	SEF	Total
1987	18	29	57		20		124
1988	6		90		19		115
1989			4		30		34
1990			253		18		271
1991	11		173		8		192
1992			162		36		198
1993			75		29		104
1994			171				171
1995	2		68				70
1996	1		77				78
1997			316				316
1998			219				219
1999			89				89
2000			130				130
2001			49				49
2002	40		162	2			204
2003	17		218				235
2004	9		229			1	239
2005	13		191				204
2006			251			4	255
2007			182				182
Total	117	29	3,166	2	160	5	3,479
% of Total	3.36	0.83	91.00	0.06	4.60	0.14	100

Table 5. Annual numbers of Spanish mackerel from Atlantic tournament samples, 1987-1993, 1999, 2003-2004, and 2007, aged by NMFS Panama City.

Year	NC	SC	GA	Total
1987	1	6	19	26
1988	1	43	18	62
1989			171	171
1990	28	10	72	110
1991		1	210	211
1992	2	4	36	42
1993	21			21
1999	5			5
2003	86			86
2004	2			2
2007	2			2
Total	148	64	526	738
% of Total	20.05	8.67	71.27	100

Table 6. Annual numbers of commercial Spanish mackerel samples by gear type aged by NMFS Panama City. CN = cast net, GN = gill net, GL = hook and line, Other = fly nets, seine nets, pound nets, sink nets, trammel nets, seine nets, UNK = unknown.

Year	CN	GN	HL	Other	UNK	Total
1990		80	41	31		152
1991		175		27	1	203
1992		190	81	182	60	513
1993		150		27	58	235
1994		10	6		16	32
1995		167	25	27		219
1996		417	35	34		486
1997	34	246	19	42		341
1998		363	31	133		527
1999		447	120	61		628
2000	3	586	147	60		796
2001	110	315	242	80		747
2002		336	61	47	853	1,297
2003		313				313
2004		524	2	18		544
2005	147	249	5	12		413
2006	212	284		2		498
2007	50	213	177			440
Total	556	5,065	992	783	988	8,384
% of Total	6.63	60.41	11.83	9.34	11.78	100

Table 7. Annual numbers of Spanish mackerel samples by source aged by NMFS Panama City. HB = Beaufort Lab Head Boat Survey, MRFSS = Marine Fisheries Recreational Statistical Survey, NCDMR = North Carolina Department of Natural Resources, RECFIN = Gulf State's Marine Fisheries Recreational Statistical Survey, TIP = Trip Interview Program, VIMS = Virginia Institute of Marine Science, UNK = unknown.

Year	HB	MRFSS	NCDNR	RECFIN	TIP	VIMS	UNK	Total
1987							258	258
1988							184	184
1989							208	208
1990			379		17		179	575
1991			306		329		14	649
1992			453		337		14	804
1993			268		195			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		38	333		359	853		1,583
2003		12	318		316			646
2004	3	3	280	1	507			794
2005		5	285	7	401			698
2006	4		277		496			777
2007			295		373			668
Total	7	58	5,698	8	5,820	957	857	13,405
% of Total	0.05	0.43	42.51	0.06	43.42	7.14	6.39	100

Table 8. Indices of precision from reader comparisons. APE = average percent error, CV = coefficient of variation, and D = index of precision.

Reader Pair	Data years	Ageing method	APE	CV	D
1 and 2	01-02, 02-03	Whole and sectioned	2.43%	2.90%	1.71%
1 and 2	06	Whole	1.48%	2.09%	1.04%
2 and 3	05-06, 07	Sectioned	3.87%	5.48%	2.74%

Table 9. Mean observed fork length (FL) at age in millimeters, standard error, and 95% confidence limits for commercially- and recreationally-caught female Spanish mackerel aged by NMFS Panama City.

	Commerical					Recreational				
Age	N	Mean FL mm	Std. Error	Lower 95% CL	Upper 95% CL	N	Mean FL mm	Std. Error	Lower 95% CL	Upper 95% CL
0	318	335.3	2.05	331.2	339.3	120	327.3	3.41	320.5	334.0
1	1,561	384.3	1.29	381.8	386.8	998	363.9	1.25	361.4	366.4
2	1,237	443.9	1.50	440.9	446.8	267	439.9	3.14	433.7	446.1
3	855	477.0	2.03	473.0	481.0	146	482.0	5.49	471.1	492.8
4	577	525.0	2.57	520.0	530.1	126	558.6	5.93	546.8	570.3
5	256	551.9	3.72	544.5	559.2	70	608.2	7.26	593.7	622.7
6	119	579.6	5.49	568.7	590.5	37	606.3	10.03	585.9	626.6
7	61	592.3	7.21	577.9	606.7	25	644.0	17.25	608.4	679.6
8	22	610.8	8.41	593.3	628.3	16	648.5	25.46	594.2	702.8
9	8	631.3	13.20	600.0	662.5	3	666.7	31.93	529.3	804.0
10	4	605.3	16.48	552.8	657.7	2	677.5	42.50	137.5	1217.5
11	0					2	742.0	18.00	513.3	970.7

Table 10. Mean observed fork length (FL) at age in inches, standard error, and 95% confidence limits for commercially- and recreationally-caught female Spanish mackerel aged by NMFS Panama City.

	Commerical					Recreational				
Age	N	Mean FL in.	Std. Error	Lower 95% CL	Upper 95% CL	N	Mean FL in.	Std. Error	Lower 95% CL	Upper 95% CL
0	318	13.2	0.08	13.0	13.4	120	12.9	0.13	12.6	13.2
1	1,561	15.1	0.05	15.0	15.2	998	14.3	0.05	14.2	14.4
2	1,237	17.5	0.06	17.4	17.6	267	17.3	0.12	17.1	17.6
3	855	18.8	0.08	18.6	18.9	146	19.0	0.22	18.5	19.4
4	577	20.7	0.10	20.5	20.9	126	22.0	0.23	21.5	22.5
5	256	21.7	0.15	21.4	22.0	70	23.9	0.29	23.4	24.5
6	119	22.8	0.22	22.4	23.2	37	23.9	0.40	23.1	24.7
7	61	23.3	0.28	22.8	23.9	25	25.4	0.68	24.0	26.8
8	22	24.0	0.33	23.4	24.7	16	25.5	1.00	23.4	27.7
9	8	24.9	0.52	23.6	26.1	3	26.2	1.26	20.8	31.7
10	4	23.8	0.65	21.8	25.9	2	26.7	1.67	5.4	47.9
11	0					2	29.2	0.71	20.2	38.2

Table 11. Mean observed fork length (FL) at age in millimeters, standard error, and 95% confidence limits for commercially- and recreationally-caught male Spanish mackerel aged by NMFS Panama City.

	Commerical					Recreational				
Age	N	Mean FL mm	Std. Error	Lower 95% CL	Upper 95% CL	N	Mean FL mm	Std. Error	Lower 95% CL	Upper 95% CL
0	298	330.3	1.84	326.6	333.9	101	316.7	3.88	309.0	324.4
1	904	355.0	1.28	352.5	357.5	967	342.4	0.97	340.5	344.3
2	665	405.2	1.57	402.1	408.2	250	396.9	2.49	392.0	401.8
3	511	442.4	2.51	437.4	447.3	99	424.7	4.40	416.0	433.5
4	362	479.0	3.25	472.6	485.4	52	459.4	8.27	442.8	476.0
5	206	506.0	4.61	496.9	515.1	23	475.3	11.31	451.9	498.8
6	111	524.2	6.26	511.8	536.6	18	508.7	16.14	474.7	542.8
7	51	535.6	7.96	519.6	551.6	15	540.0	18.23	500.9	579.1
8	27	536.2	8.11	519.5	552.9	4	568.3	38.79	444.8	691.7
9	14	532.2	12.07	506.1	558.3	1	475.0	0.00		
10	5	543.9	23.50	478.6	609.2	0				
11	0					1	555.0	0.00		

Table 12. Mean observed fork length (FL) at age in inches, standard error, and 95% confidence limits for commercially- and recreationally-caught male Spanish mackerel aged by NMFS Panama City.

	Commerical					Recreational				
Age	N	Mean FL in.	Std. Error	Lower 95% CL	Upper 95% CL	N	Mean FL in.	Std. Error	Lower 95% CL	Upper 95% CL
0	298	13.0	0.07	12.9	13.1	101	12.5	0.15	12.2	12.8
1	904	14.0	0.05	13.9	14.1	967	13.5	0.04	13.4	13.6
2	665	16.0	0.06	15.8	16.1	250	15.6	0.10	15.4	15.8
3	511	17.4	0.10	17.2	17.6	99	16.7	0.17	16.4	17.1
4	362	18.9	0.13	18.6	19.1	52	18.1	0.33	17.4	18.7
5	206	19.9	0.18	19.6	20.3	23	18.7	0.45	17.8	19.6
6	111	20.6	0.25	20.2	21.1	18	20.0	0.64	18.7	21.4
7	51	21.1	0.31	20.5	21.7	15	21.3	0.72	19.7	22.8
8	27	21.1	0.32	20.5	21.8	4	22.4	1.53	17.5	27.2
9	14	21.0	0.48	19.9	22.0	1	18.7			
10	5	21.4	0.93	18.8	24.0	0				
11	0					1	21.9			

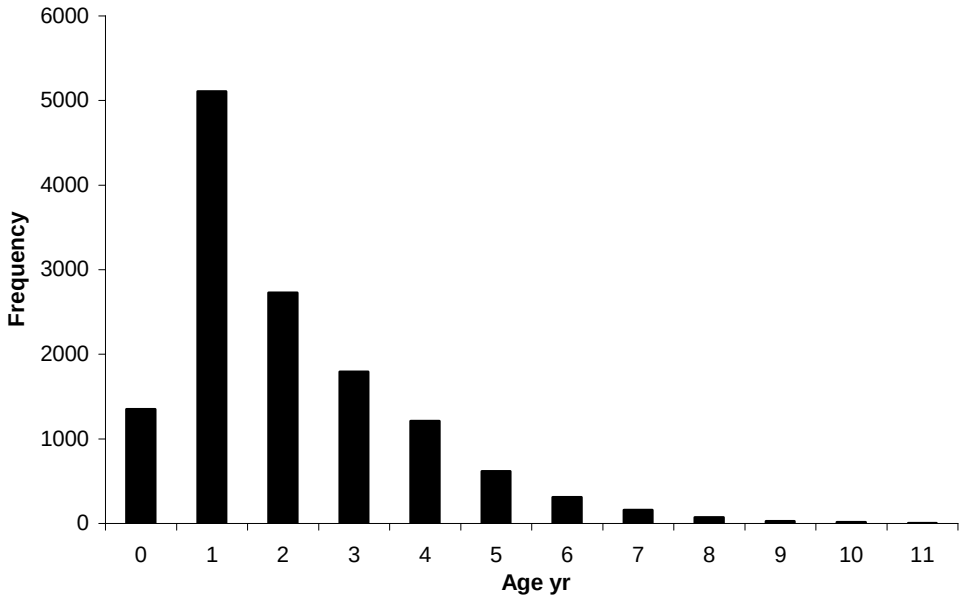


Figure 1. Age distribution of all Spanish mackerel, 1987-2007, aged by NMFS Panama City.

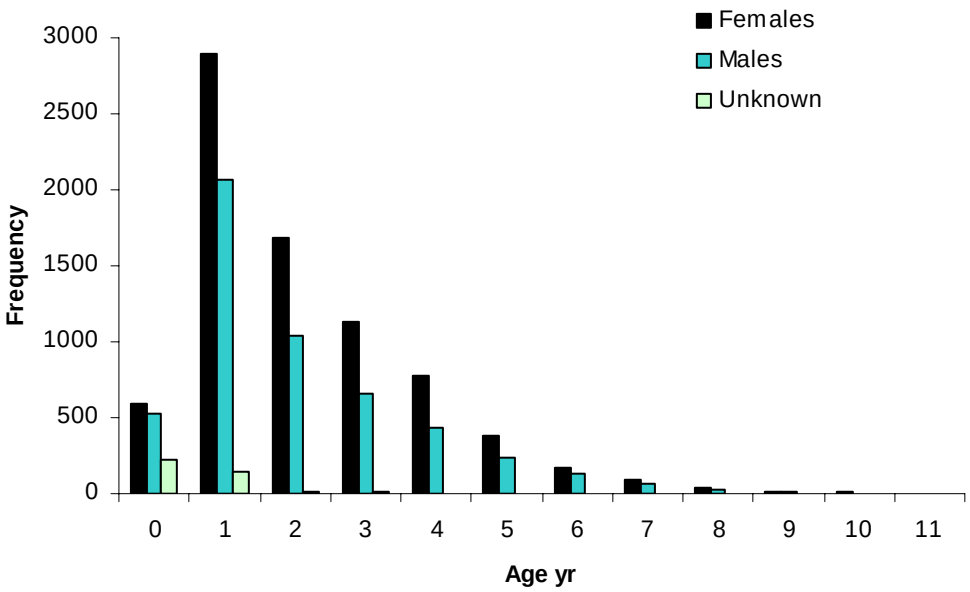


Figure 2. Age distributions of Spanish mackerel from Atlantic waters by sex, 1987-2007, aged by NMFS Panama City.

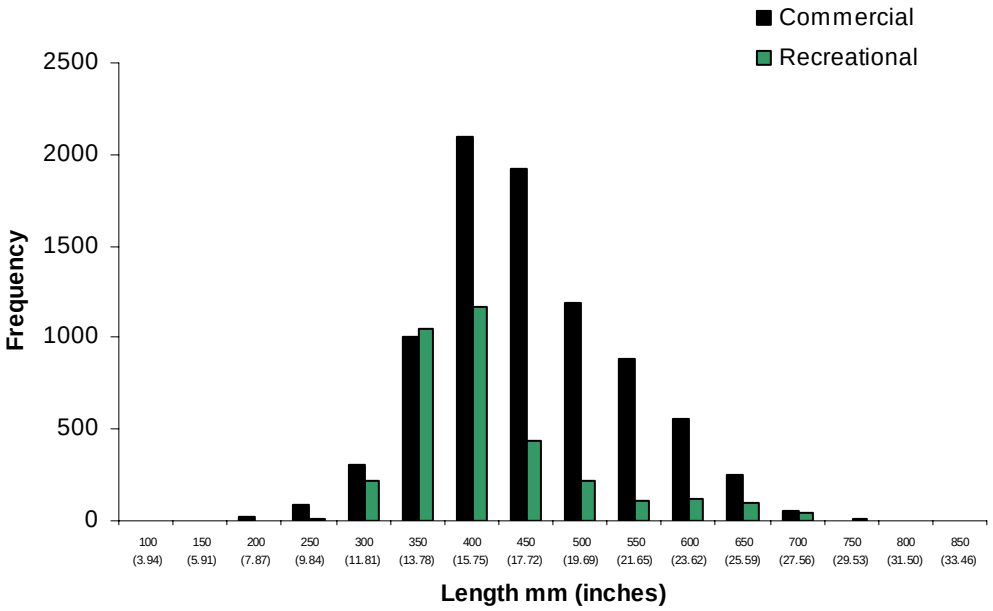


Figure 3. Size distributions of commercially- and recreationally-caught Spanish mackerel from Atlantic waters, 1987-2007, aged by NMFS Panama City.

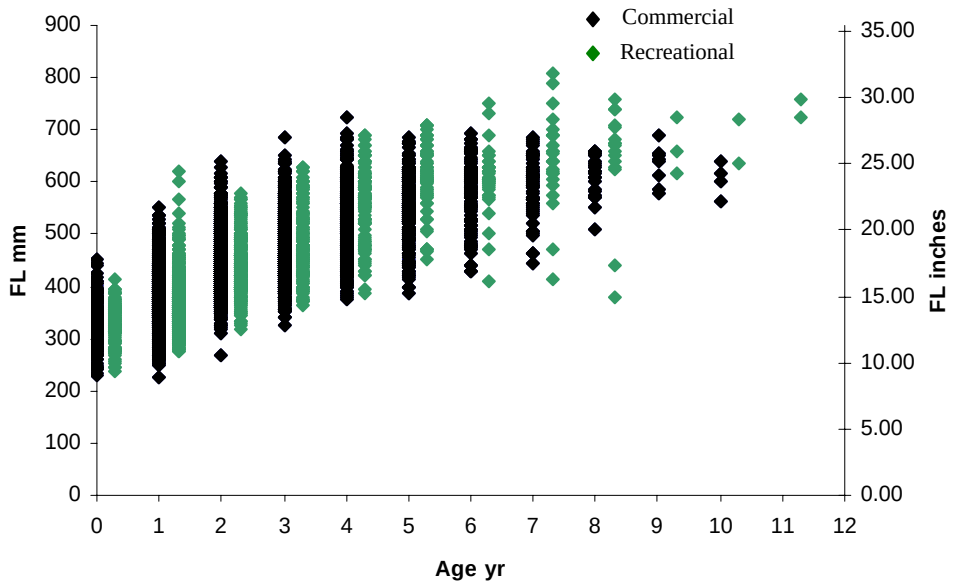


Figure 4. Length at age distributions of commercially- and recreationally-caught female Spanish mackerel from Atlantic waters, 1987-2007, aged by NMFS Panama City.

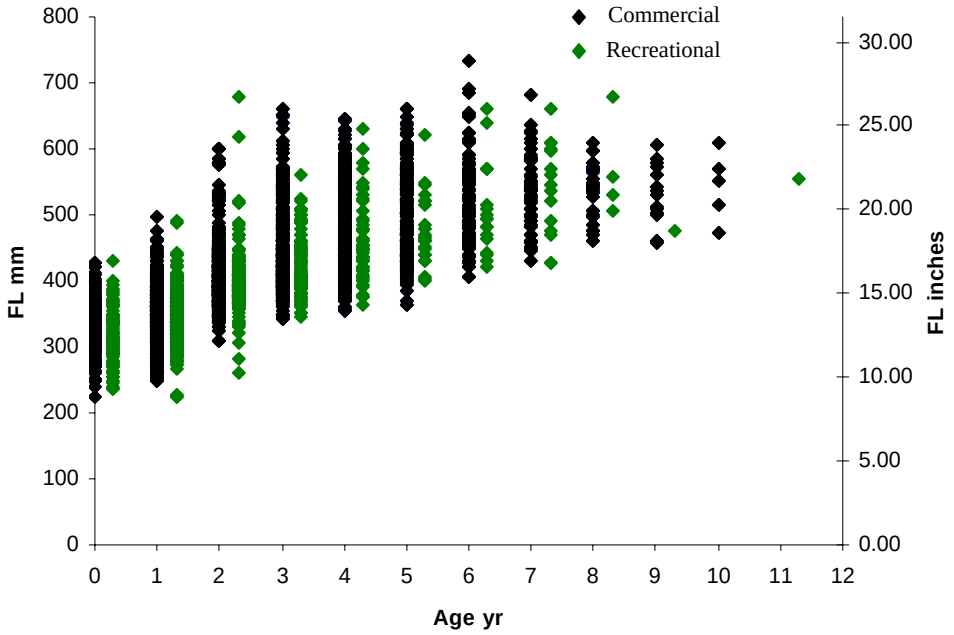


Figure 5. Length at age distributions of commercially- and recreationally-caught male Spanish mackerel from Atlantic waters, 1987-2007, aged by NMFS Panama City.

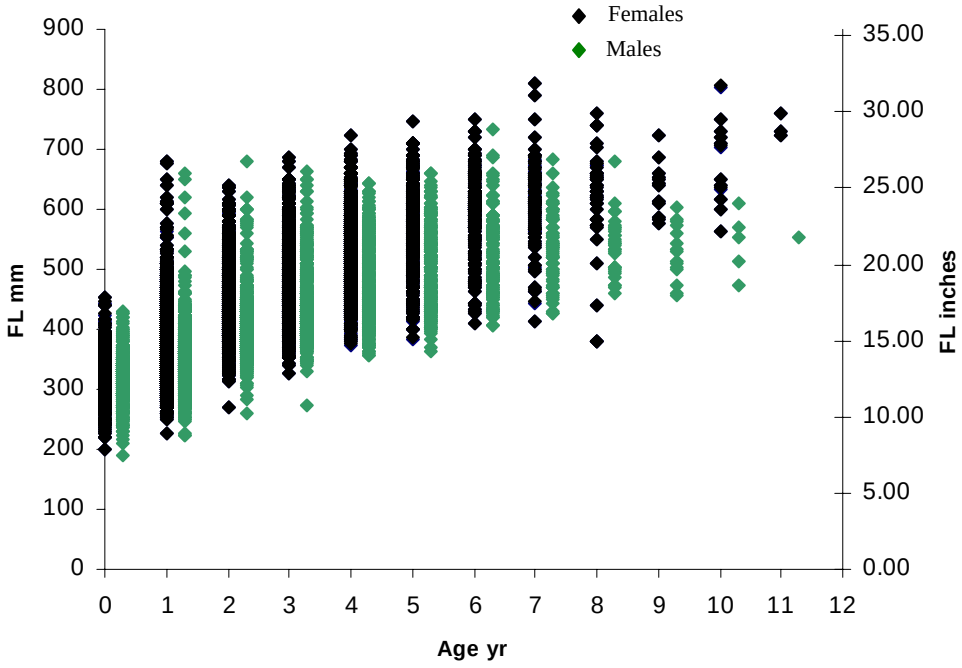


Figure 6. Length at age by sex, all sectors combined, of Spanish mackerel from Atlantic waters, 1987-2007, aged by NMFS Panama City.