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SEDAR81-WP-06

21 December 2022

Please cite this document as:

Stevens, Molly H. 2022. Gulf of Mexico Spanish Mackerel (*Scomberomorus maculatus*) Recreational Landings Length and Age Compositions. SEDAR81-WP-06. SEDAR, North Charleston, SC. 22 pp.

Gulf of Mexico Spanish Mackerel (*Scomberomorus maculatus*) Recreational Landings Length and Age Compositions

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December 2022

Introduction

This document outlines the data and methodologies used to estimate length and age compositions of recreational landings for the SEDAR 81 Gulf of Mexico Spanish Mackerel Assessment. These compositions were estimated using data sources approved in SEDAR 28. While SEDAR 28 included nominal length compositions with all modes aggregated, the Center of Independent Experts (CIE) Review recommended considering post-stratification prior to combining data for compositions (Cordue 2013). Therefore, mode-specific recreational length compositions weighted annually with spatially stratified landings data were explored. Resulting analyses, data limitations, and research recommendations are discussed below.

Because fishery-dependent sampling is typically opportunistic, sampled lengths may not be representative of the true size composition of landings (and, by extension, sampled otoliths may not be representative of the true age composition of the landings). To account for these potential biases, length samples from recreational fleets were weighted by their respective landings at the finest spatial and temporal scale available without losing data. Age data were considered conditional on the length data, therefore conditional age-at-length (CAAL) and mean length-at-age (MLAA) were estimated because these data contain more detailed information on the relationship between size and age while avoiding double use of fish (Thorson et al. 2017, Methot et al. 2020).

Data Description

SEDAR 81 assesses all Gulf of Mexico Spanish Mackerel in federal waters extending northward from the Texas/Mexico border and eastward to the Dade-Monroe county line. Following decisions from SEDAR 28, private, charterboat, and shore data from the Marine Recreational Information Program (MRIP) included all of Monroe county. Headboat data from the Southeast Regional Headboat Survey (SRHS) excluded Monroe county data from the Atlantic side of the Florida Keys as that program collects data at a finer spatial resolution than MRIP. Length data from recreational fisheries of the Gulf of Mexico are collected by multiple state and federal agencies. Recreational sources utilized were MRIP (1981-2021), Texas Parks and Wildlife Department's Marine Sport-Harvest Monitoring Program (TPWD, 1981-2021), SRHS (1986-2021), and the Gulf States Marine Fisheries Commission's Fisheries Information Network (GulfFIN) which includes multiple Gulf state sources (2001-2021). Age estimates from GulfFIN and FWRI-Fishery Independent Monitoring were compiled by the SEFSC Panama City Laboratory alongside their age data.

Recreational fleets were defined by private (PR), shore (SH) and headboat/charter (HC) modes, where headboat and charter modes were comprised of similar length compositions in time and space and aggregated due to sample size limitations. These data were compiled using length bins of 2

centimeters (cm) to match SEDAR 28. Total length (TL) was converted to fork length (FL) using the following conversion equation:

$$FL = -1.18218 + 0.8816 * TL$$

Since 1983, the recreational fisheries have had a minimum size limit of 12in (30cm) FL in Gulf federal waters. Fish landings measuring less than 10cm FL were deleted as these were assumed to be unit errors (e.g. fish recorded as 10cm were likely 10"). Fish lengths greater than 1.4m FL were deleted and assumed to be errors, while fish measuring more than 75cm FL were aggregated into a 'plus-length' group.

Recreational Length Compositions of Landings

Because fishery-dependent sampling is typically opportunistic, lengths may not be representative of the true landings composition throughout the entire Gulf of Mexico. Possible sampling bias in the collection of length samples are typically removed by weighting the length compositions with the associated landings on the finest spatial and temporal scale available without losing data.

Recreational fleets (PR, SH, HC) were aggregated into three subregions in the Gulf of Mexico based on county landed, where potential breaks were constrained by MRIP and SRHS sampling design: Eastern (E: FL Monroe-FL Levy), Central (C: FL Dixie-MS), and Western (W: LA-TX). SRHS data facilitated this break in their survey design in the Gulf of Mexico shown in Figure 1: Eastern (E: 21), Central (C: 23, 28, 29) and Western (W: 24:27). While all modes were aggregated in SEDAR 28, fleets defined here appeared sufficiently distinct to support separate model inputs (Figure 2). Spatially aggregated nominal recreational length compositions are shown by mode in Figure 3. Length distributions were shown by fishing areas that were subsequently grouped within subregion (E, C, W) for headboat (Figure 4), charter (Figure 5), private (Figure 6), and shore (Figure 7). Headboat and charter modes are shown separately here because SRHS samples on a finer spatial resolution compared to MRIP and state surveys. Sample sizes of recreational lengths (Table 1) and trips (Table 2) were provided for each strata (year, subregion) for each fleet. Strata with less than 30 length samples or less than 10 trips were dropped from further analyses.

Within each fleet, subregional-specific nominal length compositions were estimated using length bins of 2 cm, where for each year i, length bin j, and subregion r

$$LC_{i,j,r} = \frac{n_{i,j,r}}{n_{i,r}}$$

$n_{i,j,r}$ is the number of samples in year i, subregion r, and lower inclusive length bin j; $n_{i,r}$ is the number of samples in year i and subregion r; and $LC_{i,j,r}$ is the proportion of the total number of sampled fish in each year i and subregion r within each lower inclusive length bin j. A minimum sample size threshold was applied annually within each strata, $LC_{i,r}$, where these were dropped and excluded from further analyses if $n_{i,r} < 30$ or if the number of trips sampled was less than 10. Next, the remaining subregional-specific length compositions were weighted based on the distribution of the landings estimates among subregions.

Proportions of annual landings from each subregion, $p_{i,r}$, were used to weight the subregional length compositions, $LC_{i,j,r}$, which were then summed across subregions r

$$LC_{i,j} = \sum_{r} \left(LC_{i,j,r} * p_{i,r} \right)$$

resulting in the final weighted estimates of landings length compositions, $LC_{i,j}$. The proportion of landings, $p_{i,r}$, for each year i and subregion r are shown in Table 3. This procedure would downweight, for example, any instances where 60% of the length samples come from a stratum that only accounts for 20% of the landings for that fleet. The effects of this weighting procedure are shown for headboat/charter (Figure 8), private (Figure 9), and shore modes (Figure 10).

Recreational Conditional Age-at-Length

Recreational age samples were a subset of the length samples. Age data compiled by the SEFSC Panama City Laboratory were filtered to remove duplicated and biased data. Sample sizes of recreational ages (Table 4) and recreational trips sampled for age (Table 5) were provided. The western subregion rarely collects otoliths for ageing, but this subregion is also associated with low landings throughout the duration of the available data (<5%). Spanish Mackerel maximum age was estimated to be 11 years.

Within each recreational fleet (PR, SH, HC) conditional age-at-length was estimated where for each year i, length bin j, and age class k

$$CAAL_{i,j,k} = \frac{a_{i,j,k}}{a_{i,j}}$$

$a_{i,j,k}$ is the number of age samples in year i, lower inclusive length bin j, and age class k; $a_{i,j}$ is the number of age samples in year i and lower inclusive length bin j; and $CAAL_{i,j,k}$ is the proportion of fish samples in year i and length bin j within age class k (Figure 11, Figure 12, and Figure 13).

Fleet-specific mean length-at-age and associated sample sizes were also provided to aide in model diagnostics. Mean length-at-age, $MLAA_{i,k}$, was estimated as the sum of all lengths $L_{i,k}$ divided by the associated sample sizes $a_{i,k}$ within each year i and age class k.

$$MLAA_{i,k} = \frac{\sum L_{i,k}}{a_{i,k}}$$

Data Limitations and Research Recommendations

Length compositions were not as consistent within subregional-temporal strata as some species with better sampling coverage. This could be due to less-targeted sampling from some regions. For example, sampling of Spanish Mackerel in Louisiana stopped when the Louisiana Department of Wildlife and Fisheries (LDWF) took over recreational data collection in 2014 from MRIP. For this assessment, LA and TX had similar length compositions so the data were aggregated, overcoming the artificial spatio-temporal data gap. This could introduce problems in the future and make weighting schemes impossible to overcome data limitations. Further issues could be explained by the migration patterns of Spanish mackerel that may vary in time and space, which could lead to inconsistent spatio-temporal patterns in the length distributions. Research recommendations include investigating more thoroughly the effects of sampling inconsistencies including the loss of Louisiana samples 2015-present and pulse of Mississippi headboat samples 2014-2019, as well as seasonal migrations.

References

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Tables

Table 1*. Annual number of Spanish Mackerel recreational headboat/charter (HC), private (PR), and shore (SH) length samples by spatial strata (W, C, E). The length compositions resulting from these samples were dropped from further analyses if n<30.*

Year	HC_W	HC_C	HC_E	PR_W	PR_C	PR_E	SH_W	SH_C	SH_E
1981	0	73	31	5	140	23	2	18	11
1982	0	135	4	45	177	12	17	63	6
1983	9	260	25	129	54	28	4	120	12
1984	6	371	3	97	30	1	0	31	5
1985	3	147	0	179	44	12	0	13	23
1986	9	448	175	51	248	32	0	7	119
1987	33	420	142	250	387	125	0	57	88
1988	23	343	31	153	143	61	0	24	30
1989	56	395	53	267	64	105	0	46	30
1990	84	344	43	243	123	95	0	85	66
1991	124	300	18	332	173	206	1	68	28
1992	78	315	29	254	367	474	8	148	187
1993	49	96	3	199	101	79	6	154	117
1994	76	87	49	285	108	133	4	131	156
1995	75	45	196	418	52	48	5	27	50
1996	65	89	28	479	96	214	0	11	103
1997	93	149	293	253	89	161	3	26	174
1998	41	375	251	214	103	336	2	11	166
1999	41	1,191	313	183	474	348	1	69	293
2000	42	1,599	470	322	251	220	0	77	163
2001	29	1,864	407	109	341	343	1	172	242
2002	99	497	848	165	170	456	0	130	231
2003	39	353	763	193	203	399	1	28	212
2004	34	523	607	286	298	295	7	109	177
2005	16	247	253	442	131	173	1	34	126
2006	50	216	373	639	211	279	1	33	152
2007	41	440	221	307	160	272	0	105	140
2008	44	565	266	335	208	269	0	49	176
2009	30	439	235	324	181	250	3	35	247
2010	33	524	390	254	165	335	0	94	214
2011	56	882	723	471	189	303	1	149	155
2012	55	1,415	738	465	195	309	1	156	125
2013	48	427	535	238	137	378	0	113	244
2014	99	675	378	339	183	347	6	49	203
2015	37	919	1,025	160	255	350	0	51	51
2016	82	956	929	382	266	204	0	65	121
2017	65	571	1,022	275	137	157	0	61	65
2018	32	618	888	307	81	148	0	39	19
2019	46	494	1,188	225	78	296	0	76	124
2020	35	390	690	165	121	220	0	37	58
2021	17	333	709	62	80	98	0	70	54

***Table 2**. Annual number of Spanish Mackerel recreational headboat/charter (HC), private (PR), and shore (SH) trips sampled for lengths by spatial strata (W, C, E). The length compositions resulting from these samples were dropped from further analyses if n<10.*

Year	HC_W	HC_C	HC_E	PR_W	PR_C	PR_E	SH_W	SH_C	SH_E
1981	0	16	4	3	40	10	2	6	8
1982	0	19	3	16	62	6	5	36	3
1983	7	33	4	80	18	12	1	36	8
1984	3	45	2	45	20	1	0	13	3
1985	3	19	0	97	20	9	0	9	5
1986	8	62	35	37	78	12	0	3	28
1987	20	78	27	107	142	57	0	29	24
1988	15	70	7	67	60	27	0	12	12
1989	24	70	13	107	24	40	0	10	13
1990	18	68	14	115	36	58	0	19	27
1991	37	54	8	159	43	86	1	22	15
1992	31	56	10	136	96	201	1	50	63
1993	24	28	3	109	42	40	6	45	30
1994	36	25	10	143	42	69	3	50	62
1995	36	10	23	212	27	31	1	10	21
1996	29	24	9	210	32	92	0	9	35
1997	38	77	67	129	31	80	2	12	51
1998	16	94	65	103	44	138	1	6	59
1999	21	240	77	112	147	134	1	28	96
2000	19	327	90	156	123	104	0	25	51
2001	21	177	68	58	93	153	1	56	79
2002	19	100	372	102	90	212	0	45	88
2003	22	94	192	99	87	224	1	10	97
2004	17	111	180	135	97	140	2	33	49
2005	11	89	54	180	50	90	1	17	41
2006	21	73	87	296	72	122	1	20	39
2007	22	91	55	131	88	149	0	34	34
2008	19	120	79	158	96	136	0	18	56
2009	17	111	50	168	84	115	1	22	74
2010	11	137	108	109	61	155	0	33	70
2011	26	240	196	200	72	127	1	44	44
2012	25	291	224	172	85	132	1	51	44
2013	23	219	105	113	68	206	0	35	74
2014	39	191	124	158	88	174	1	15	71
2015	20	252	244	74	105	142	0	25	21
2016	40	344	390	165	117	111	0	26	39
2017	31	206	245	121	66	76	0	22	19
2018	22	333	229	129	41	62	0	27	14
2019	26	121	251	91	53	109	0	35	33
2020	20	129	124	89	58	82	0	23	30
2021	13	110	152	37	42	51	0	34	22

***Table 3**. Annual distribution of recreational headboat/charter (HC), private (PR), and shore (SH) landings by subregion, where each value is the proportion of landings in numbers $p_{i,r}$ from year i and subregion r within fleets.*

Year	HC_W	HC_C	HC_E	PR_W	PR_C	PR_E	SH_W	SH_C	SH_E
1981	0.00	0.83	0.16	0.01	0.44	0.55	0.01	0.38	0.61
1982	0.00	0.99	0.01	0.08	0.88	0.04	0.15	0.62	0.23
1983	0.00	0.87	0.12	0.10	0.75	0.14	0.01	0.63	0.37
1984	0.01	0.96	0.03	0.17	0.58	0.25	0.00	0.73	0.27
1985	0.10	0.83	0.07	0.09	0.61	0.30	0.00	0.56	0.44
1986	0.00	0.45	0.55	0.01	0.61	0.38	0.00	0.08	0.92
1987	0.01	0.71	0.28	0.09	0.46	0.45	0.00	0.57	0.43
1988	0.01	0.86	0.13	0.02	0.69	0.29	0.06	0.43	0.50
1989	0.00	0.78	0.22	0.16	0.42	0.41	0.00	0.71	0.29
1990	0.00	0.13	0.87	0.09	0.43	0.48	0.00	0.37	0.63
1991	0.03	0.61	0.36	0.05	0.43	0.51	0.00	0.78	0.22
1992	0.04	0.70	0.26	0.13	0.36	0.51	0.00	0.53	0.46
1993	0.01	0.94	0.05	0.09	0.49	0.42	0.00	0.55	0.45
1994	0.02	0.44	0.54	0.02	0.56	0.42	0.00	0.40	0.60
1995	0.01	0.23	0.76	0.08	0.63	0.28	0.00	0.80	0.20
1996	0.01	0.80	0.19	0.06	0.36	0.58	0.00	0.20	0.80
1997	0.02	0.25	0.73	0.09	0.47	0.44	0.01	0.17	0.83
1998	0.01	0.68	0.31	0.02	0.27	0.71	0.01	0.37	0.62
1999	0.01	0.66	0.33	0.03	0.51	0.46	0.00	0.24	0.75
2000	0.01	0.53	0.46	0.07	0.55	0.38	0.04	0.50	0.46
2001	0.01	0.44	0.55	0.01	0.46	0.53	0.00	0.76	0.24
2002	0.01	0.33	0.65	0.03	0.22	0.75	0.00	0.55	0.45
2003	0.01	0.29	0.70	0.04	0.32	0.64	0.00	0.39	0.61
2004	0.00	0.60	0.40	0.01	0.36	0.63	0.00	0.64	0.36
2005	0.02	0.30	0.69	0.03	0.55	0.42	0.01	0.49	0.50
2006	0.01	0.07	0.92	0.03	0.25	0.72	0.00	0.18	0.82
2007	0.01	0.36	0.63	0.03	0.39	0.58	0.00	0.38	0.62
2008	0.01	0.34	0.65	0.00	0.51	0.48	0.00	0.60	0.40
2009	0.01	0.21	0.78	0.01	0.29	0.70	0.00	0.22	0.78
2010	0.00	0.29	0.71	0.03	0.41	0.56	0.00	0.35	0.65
2011	0.00	0.41	0.59	0.01	0.60	0.39	0.00	0.77	0.23
2012	0.01	0.52	0.46	0.04	0.44	0.52	0.00	0.72	0.28
2013	0.00	0.40	0.59	0.03	0.36	0.60	0.00	0.58	0.42
2014	0.02	0.49	0.49	0.01	0.22	0.77	0.00	0.23	0.77
2015	0.00	0.41	0.58	0.01	0.40	0.59	0.00	0.64	0.36
2016	0.01	0.52	0.47	0.01	0.35	0.64	0.00	0.55	0.45
2017	0.02	0.31	0.68	0.02	0.52	0.46	0.00	0.70	0.30
2018	0.01	0.29	0.70	0.01	0.39	0.60	0.00	0.57	0.43
2019	0.00	0.30	0.70	0.01	0.16	0.82	0.00	0.71	0.29
2020	0.01	0.27	0.73	0.01	0.22	0.77	0.00	0.40	0.60
2021	0.00	0.56	0.44	0.00	0.15	0.85	0.00	0.75	0.25

***Table 4**. Annual number of recreational headboat/charter (HC), private (PR), and shore (SH) age samples by stock.*

Year	HC_W	HC_C	HC_E	PR_W	PR_C	PR_E	SH_C	SH_E
1987	1	0	0	0	0	0	0	0
1988	1	0	0	0	0	0	0	0
1989	110	74	0	0	0	0	0	0
1990	53	312	29	1	1	0	0	0
1991	99	76	8	0	12	0	0	0
1992	41	183	1	0	16	0	0	0
1993	4	44	0	0	31	0	0	0
1994	0	98	0	0	1	2	0	0
1995	0	46	0	0	62	0	0	0
1996	0	245	0	0	3	0	0	0
1997	0	109	0	0	1	0	0	0
1998	0	108	0	0	21	0	0	0
1999	0	335	19	0	134	1	0	0
2000	0	153	0	0	0	0	0	0
2001	0	80	25	0	0	0	0	0
2002	0	210	132	0	4	82	0	0
2003	0	417	41	0	17	111	0	0
2004	0	100	170	0	16	51	0	0
2005	0	52	0	0	0	6	0	0
2006	0	130	2	0	0	1	0	0
2007	0	175	13	0	5	19	0	0
2008	0	257	75	0	14	56	0	0
2009	0	93	11	0	0	8	0	0
2010	0	122	87	0	5	16	0	0
2011	0	334	106	0	1	23	35	0
2012	0	521	36	0	0	6	35	2
2013	1	367	3	0	0	8	4	0
2014	0	322	9	0	30	3	0	0
2015	0	292	14	0	43	0	44	2
2016	0	175	11	0	41	0	14	0
2017	0	181	42	0	3	2	2	0
2018	0	312	67	0	6	5	23	0
2019	0	271	296	0	22	32	0	0
2020	0	112	95	0	18	30	11	52
2021	0	251	137	4	39	21	99	30

Table 5*. Annual number of recreational headboat/charter (HC), private (PR), and shore (SH) trips sampled for ages by stock.*

Year	HC_W	HC_C	HC_E	PR_W	PR_C	PR_E	SH_C	SH_E
1987	1	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0
1989	1	1	0	0	0	0	0	0
1990	1	1	1	1	1	0	0	0
1991	29	24	3	0	4	0	0	0
1992	11	32	1	0	2	0	0	0
1993	3	16	0	0	2	0	0	0
1994	0	16	0	0	1	1	0	0
1995	0	6	0	0	12	0	0	0
1996	0	25	0	0	2	0	0	0
1997	0	18	0	0	1	0	0	0
1998	0	15	0	0	1	0	0	0
1999	0	37	3	0	5	1	0	0
2000	0	1	0	0	0	0	0	0
2001	0	4	7	0	0	0	0	0
2002	0	3	8	0	0	13	0	0
2003	0	5	10	0	2	28	0	0
2004	0	2	18	0	1	13	0	0
2005	0	4	0	0	0	3	0	0
2006	0	2	2	0	0	1	0	0
2007	0	1	3	0	4	7	0	0
2008	0	4	7	0	3	15	0	0
2009	0	4	6	0	0	5	0	0
2010	0	11	7	0	2	10	0	0
2011	0	26	9	0	1	5	5	0
2012	0	28	6	0	0	4	6	1
2013	1	14	3	0	0	2	3	0
2014	0	24	6	0	6	2	0	0
2015	0	85	3	0	19	0	6	1
2016	0	62	9	0	20	0	5	0
2017	0	62	16	0	3	2	2	0
2018	0	88	25	0	4	2	9	0
2019	0	82	70	0	18	19	0	0
2020	0	47	22	0	8	17	9	24
2021	0	68	35	1	14	12	36	12

Figures

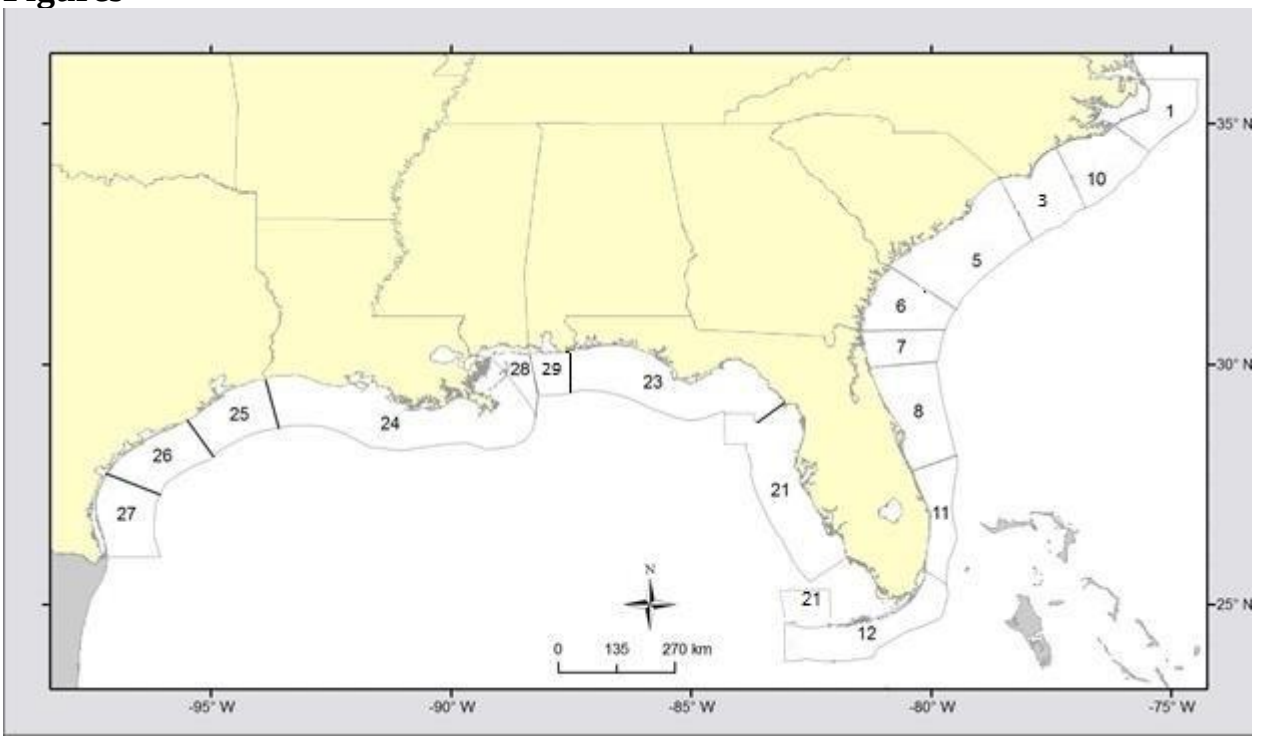

Figure 1: SRHS headboat areas in the Gulf of Mexico used to define stock boundaries. Pre-2013, Alabama could not be distinguished from the Florida panhandle (i.e. area 23 encompassed area 29 in the SRHS survey design).

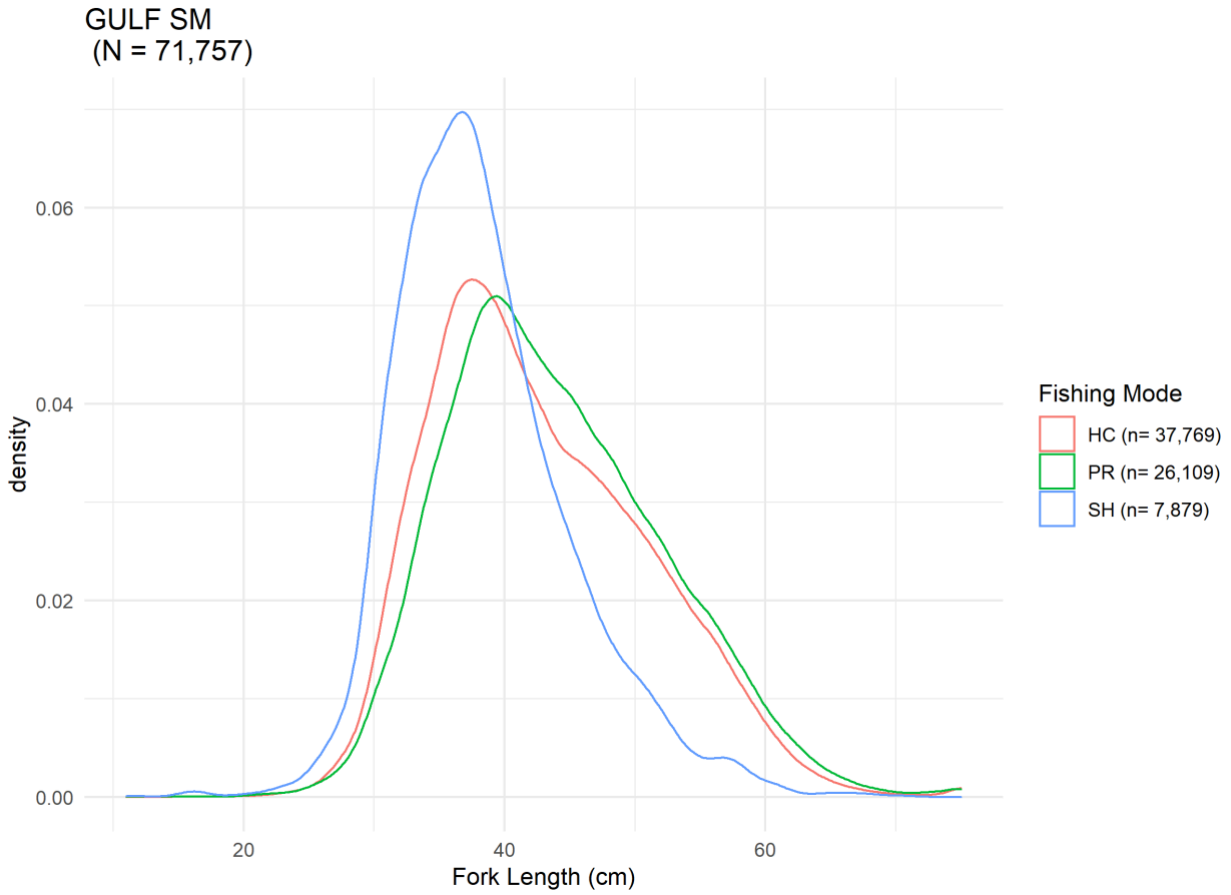

Figure 2: Annually and spatially aggregated Spanish Mackerel length distributions by recreational modes: private (PR), shore (SH), and headboat/charter (HC).

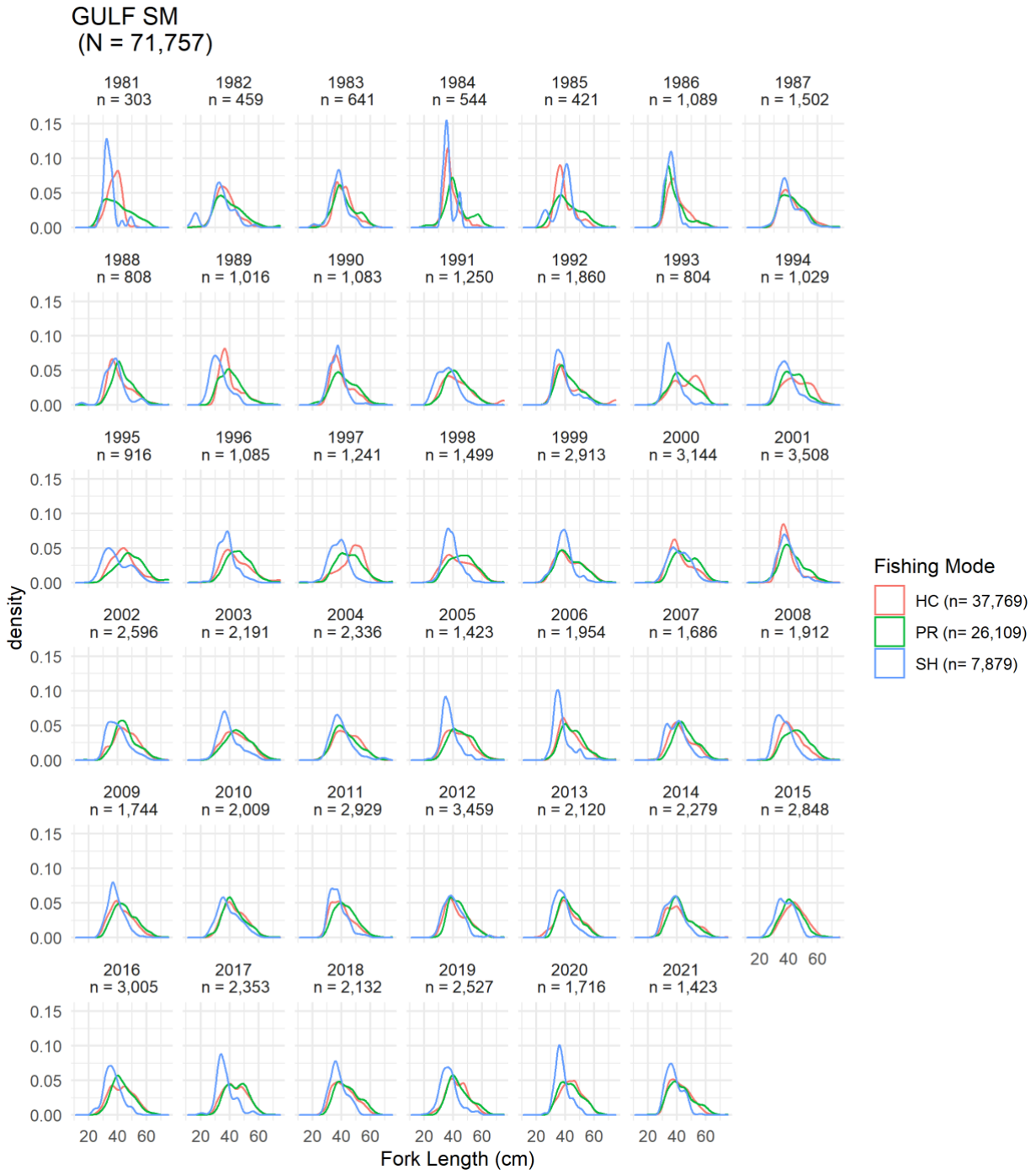

Figure 3: Spatially aggregated Spanish Mackerel length distributions by recreational modes: private (PR), shore (SH), and headboat/charter (HC). Strata with less than 30 samples were dropped.

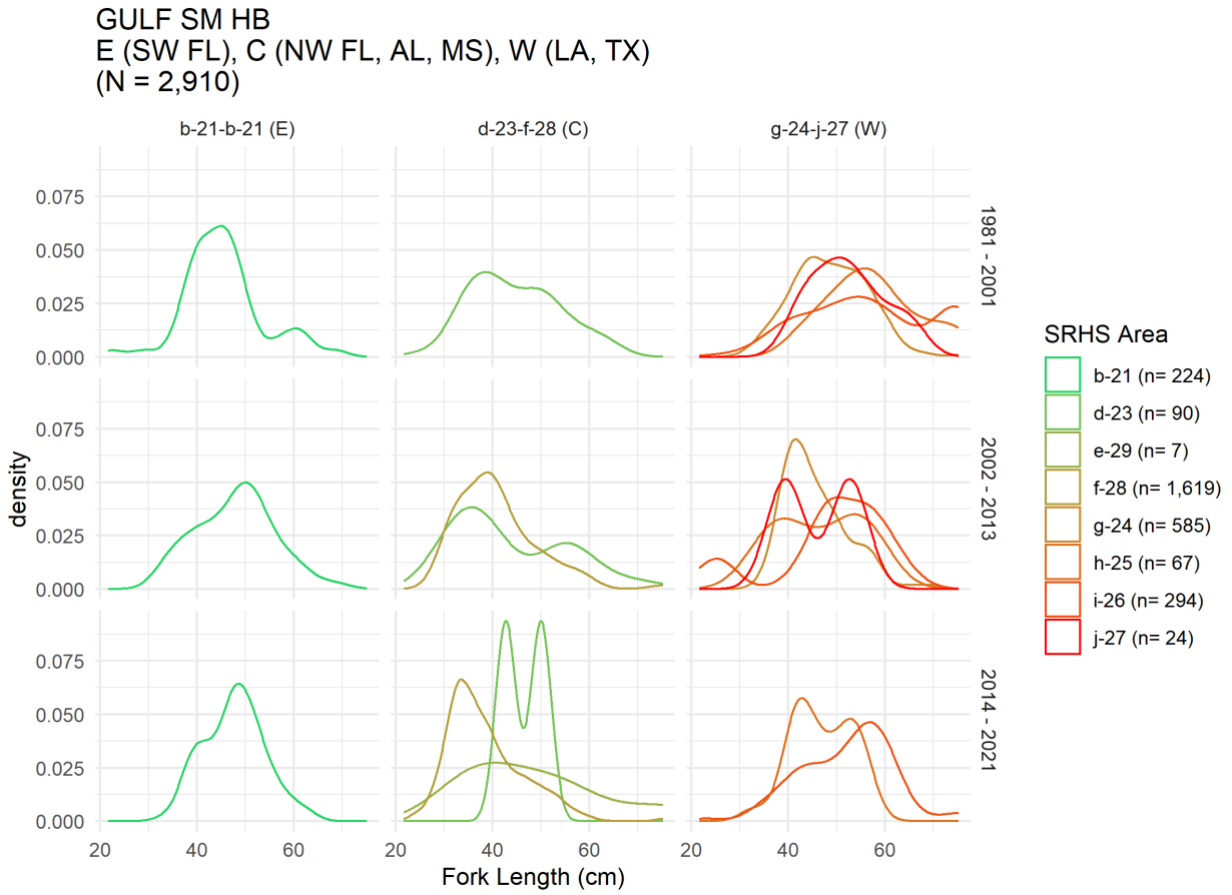

Figure 4: Annually aggregated Spanish Mackerel headboat length distributions by headboat areas for each subregion: E, C, W.

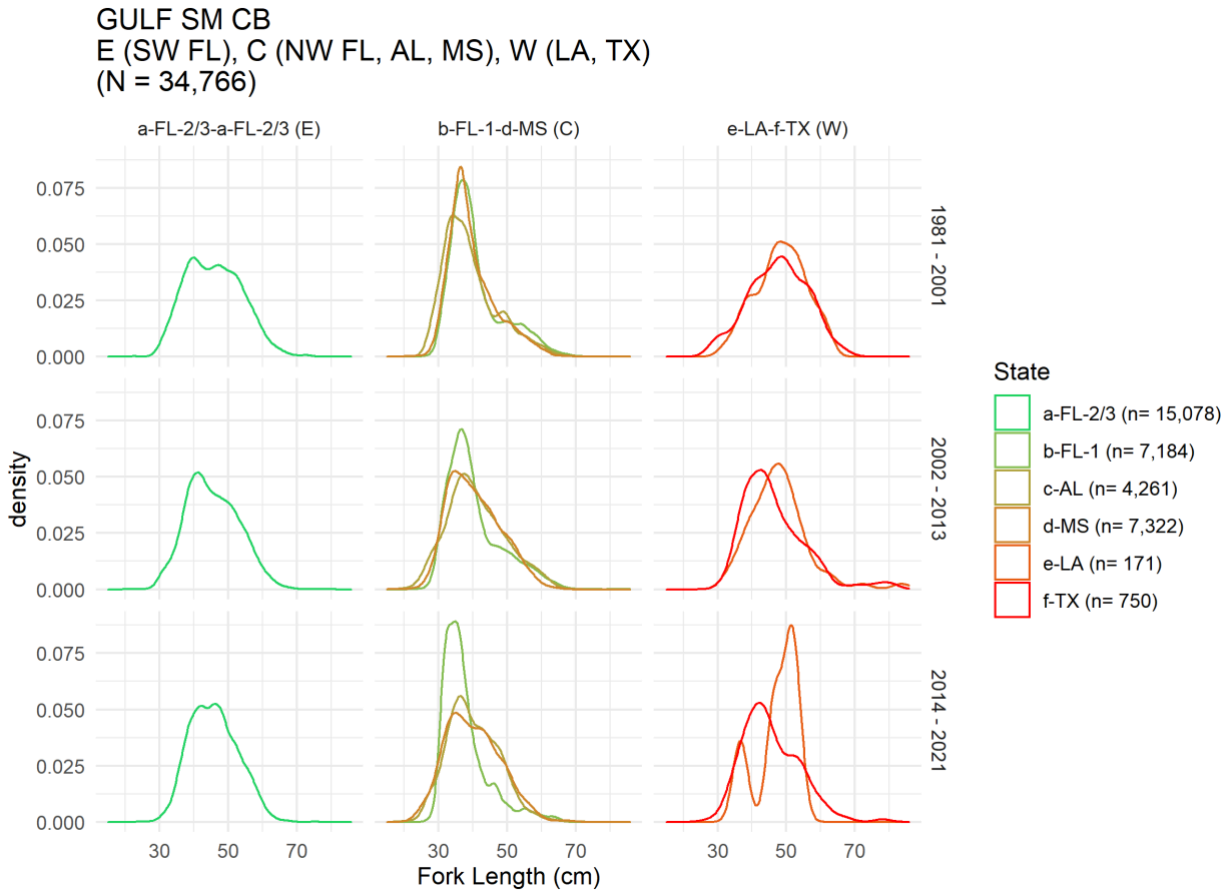

Figure 5: Annually aggregated Spanish Mackerel charterboat length distributions by MRIP areas for each stock: E, C, W.

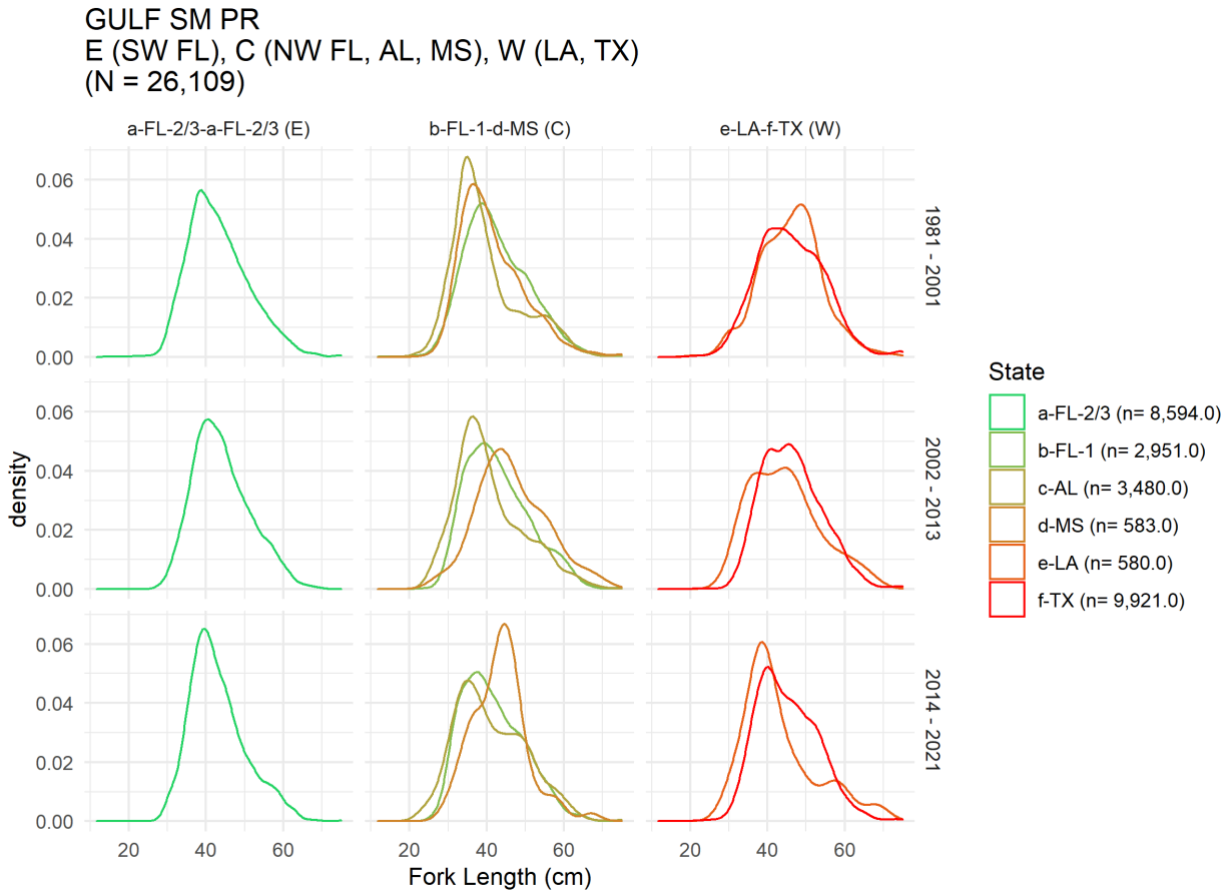

Figure 6: Annually aggregated Spanish Mackerel private mode length distributions by MRIP areas for each stock: E, C, W.

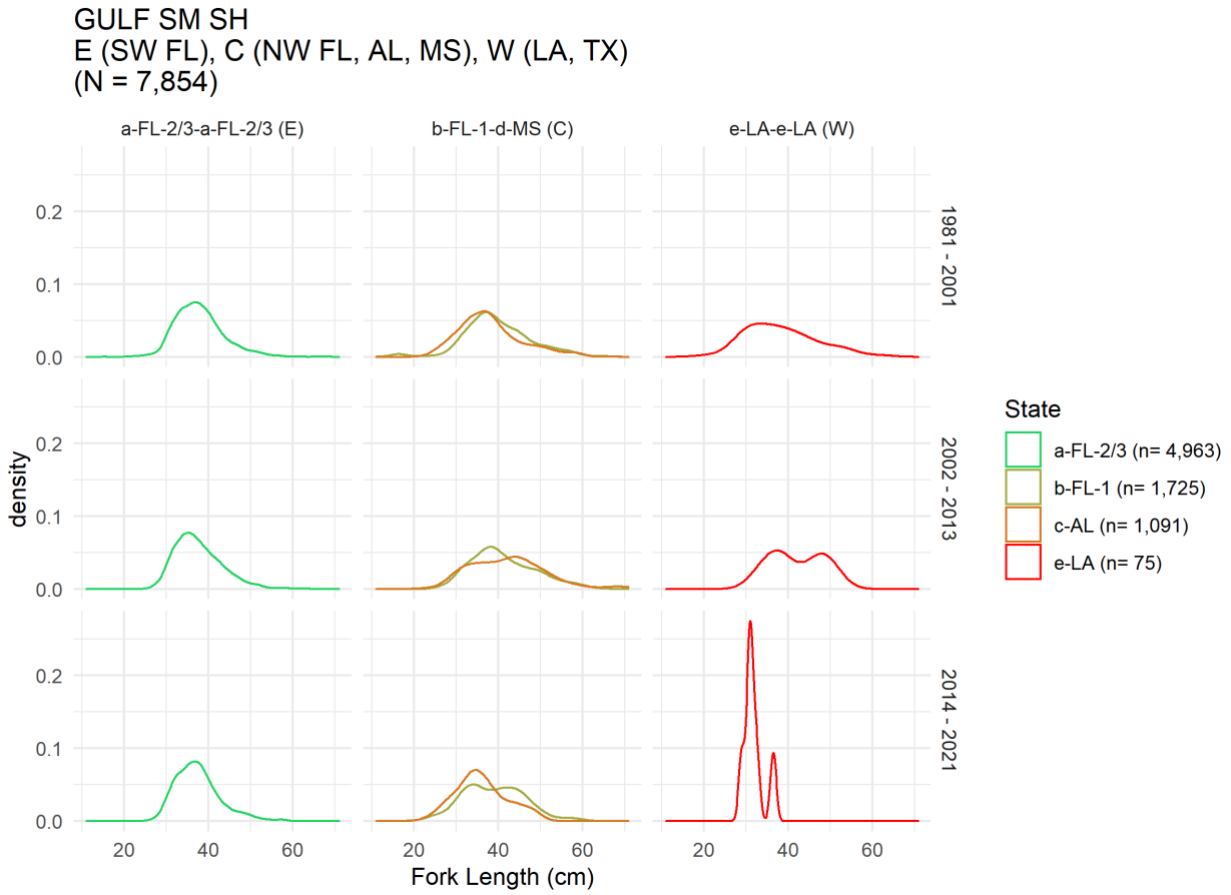

Figure 7: Annually aggregated Spanish Mackerel shore mode length distributions by MRIP areas for each stock: E, C, W.

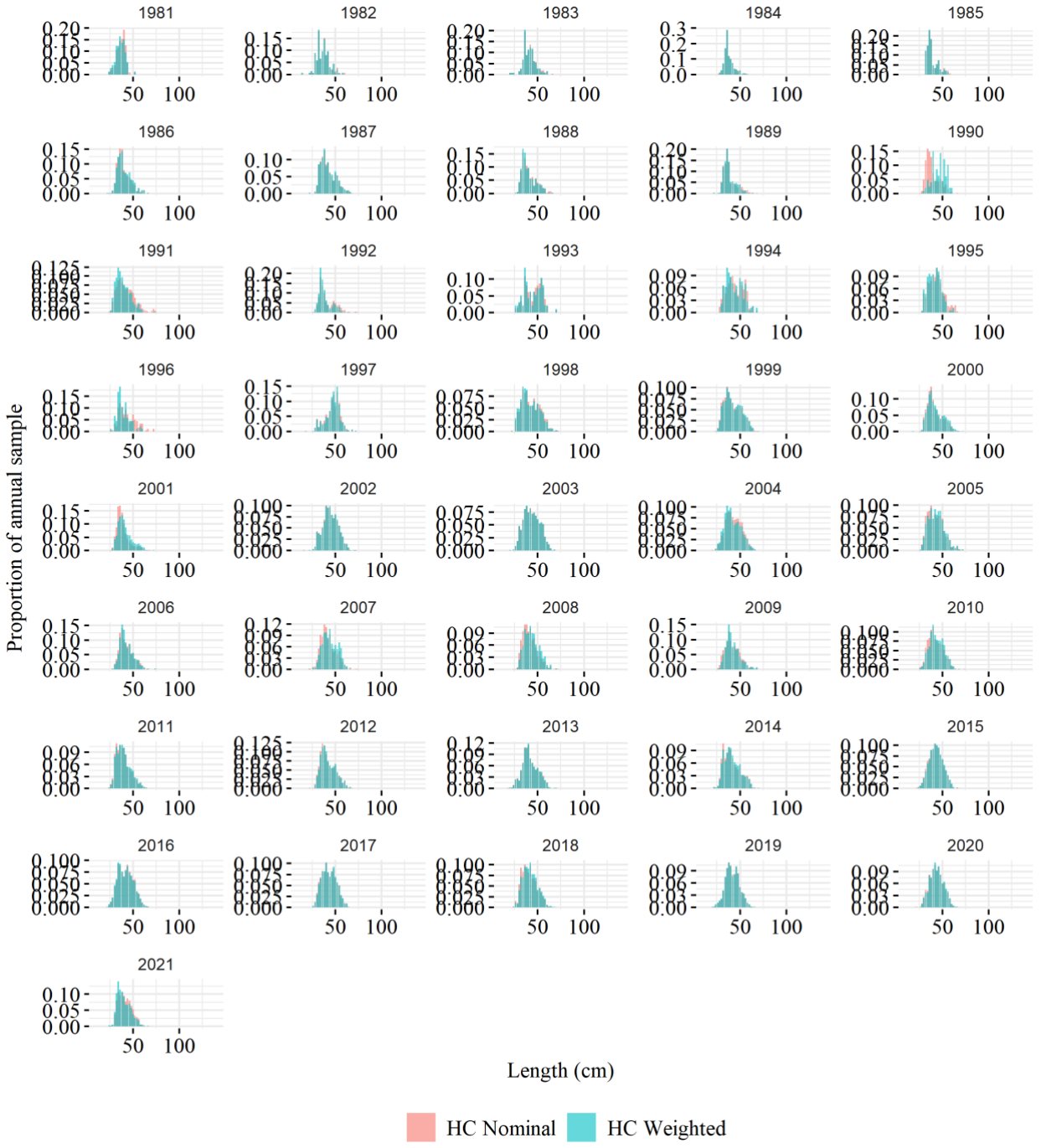

Figure 8: Nominal and weighted Spanish Mackerel length compositions from the recreational headboat/charter fleet.

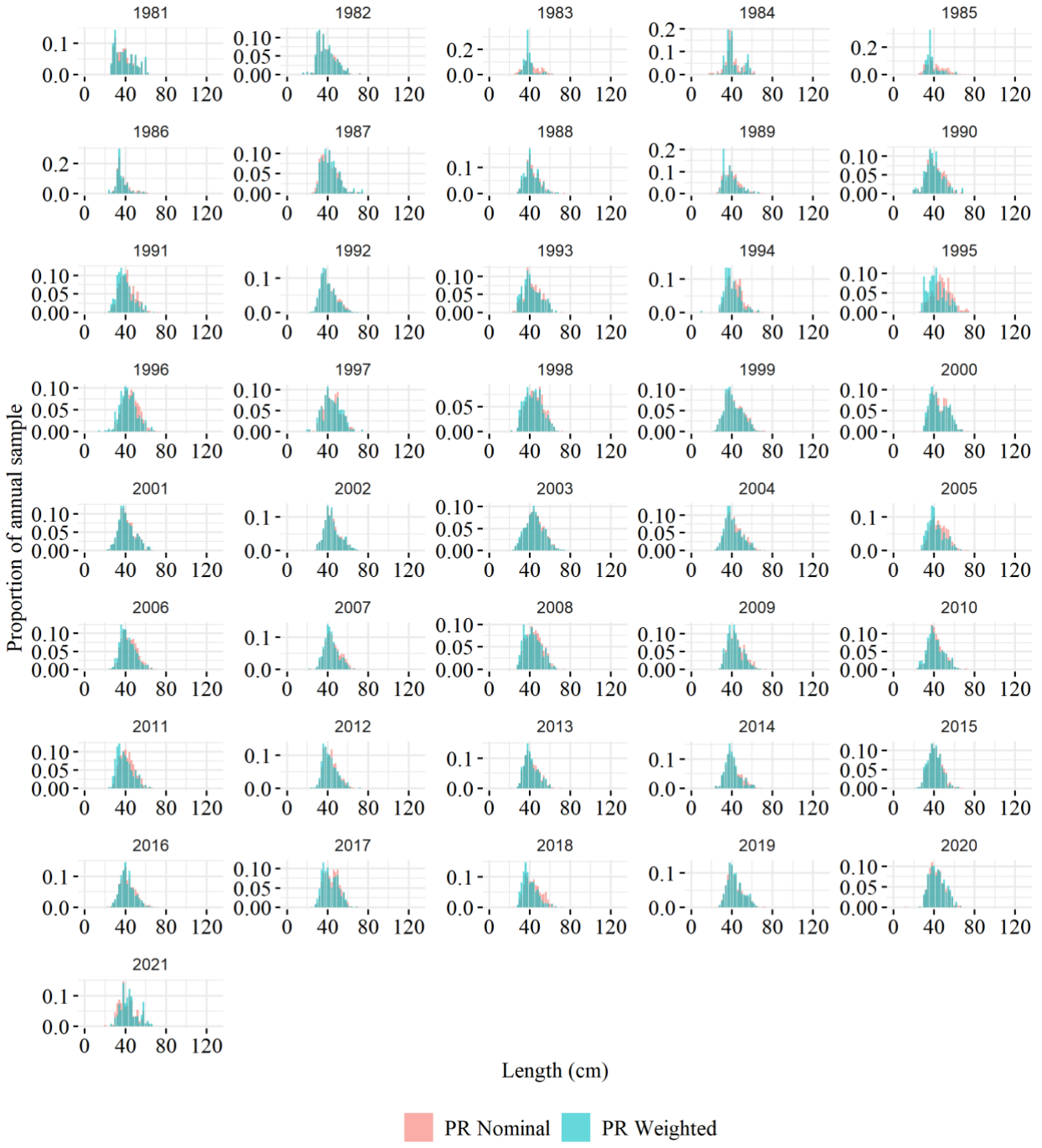

Figure 9: Nominal and weighted Spanish Mackerel length compositions from the recreational private fleet.

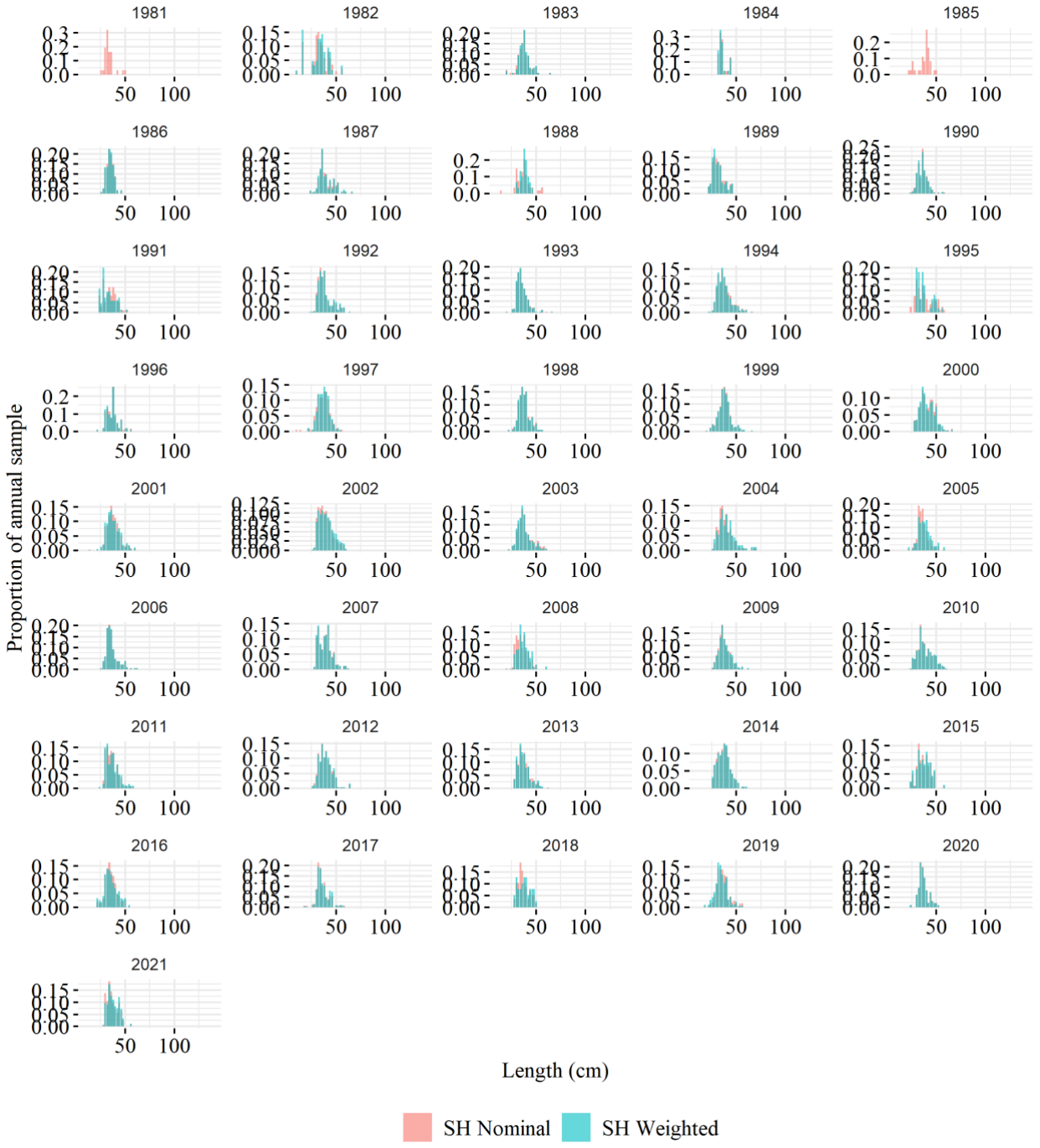

Figure 10: Nominal and weighted Spanish Mackerel length compositions from the recreational shore fleet.

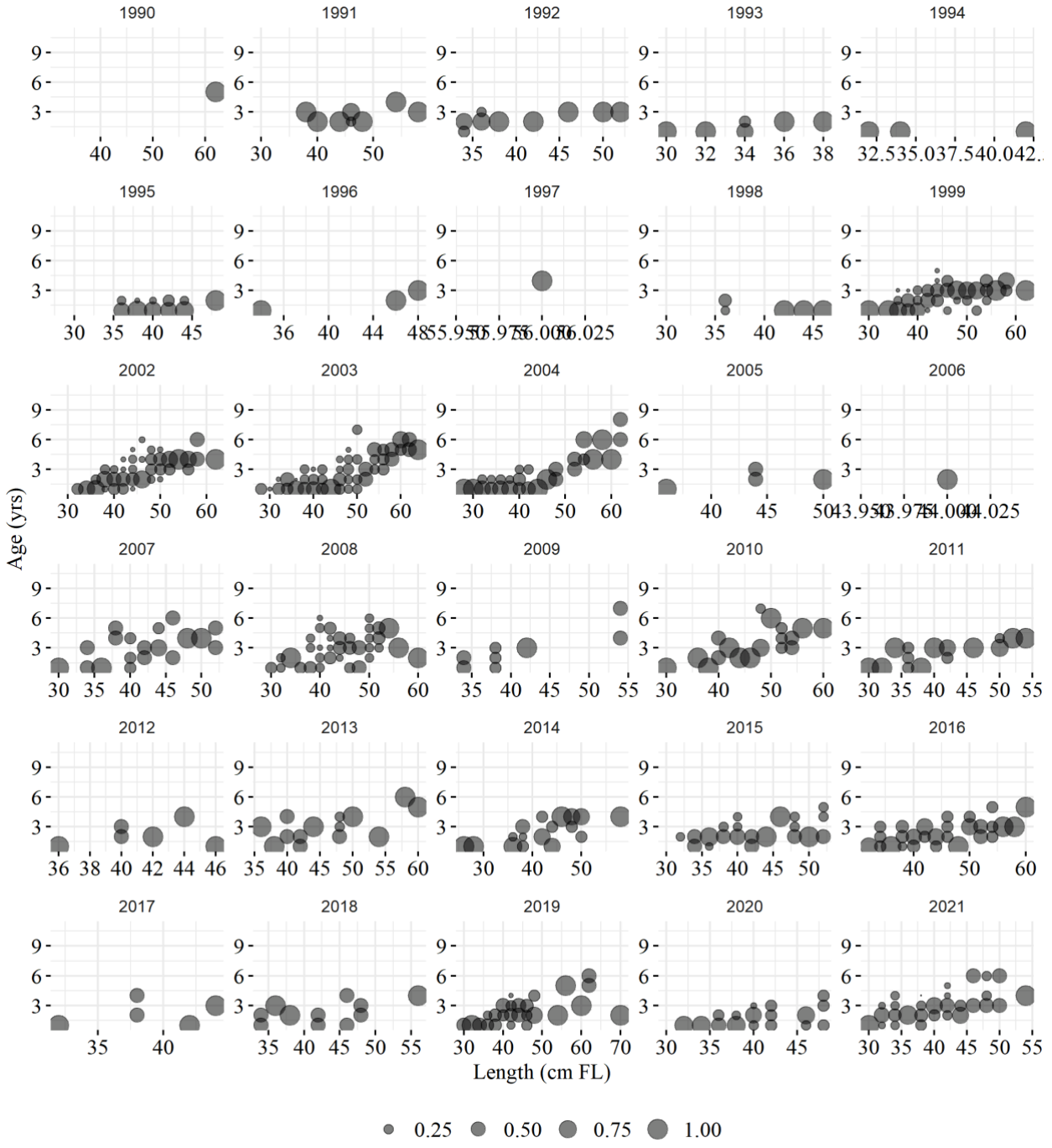

Figure 11: Annual Spanish Mackerel conditional age-at-length estimates from the recreational private fleet.

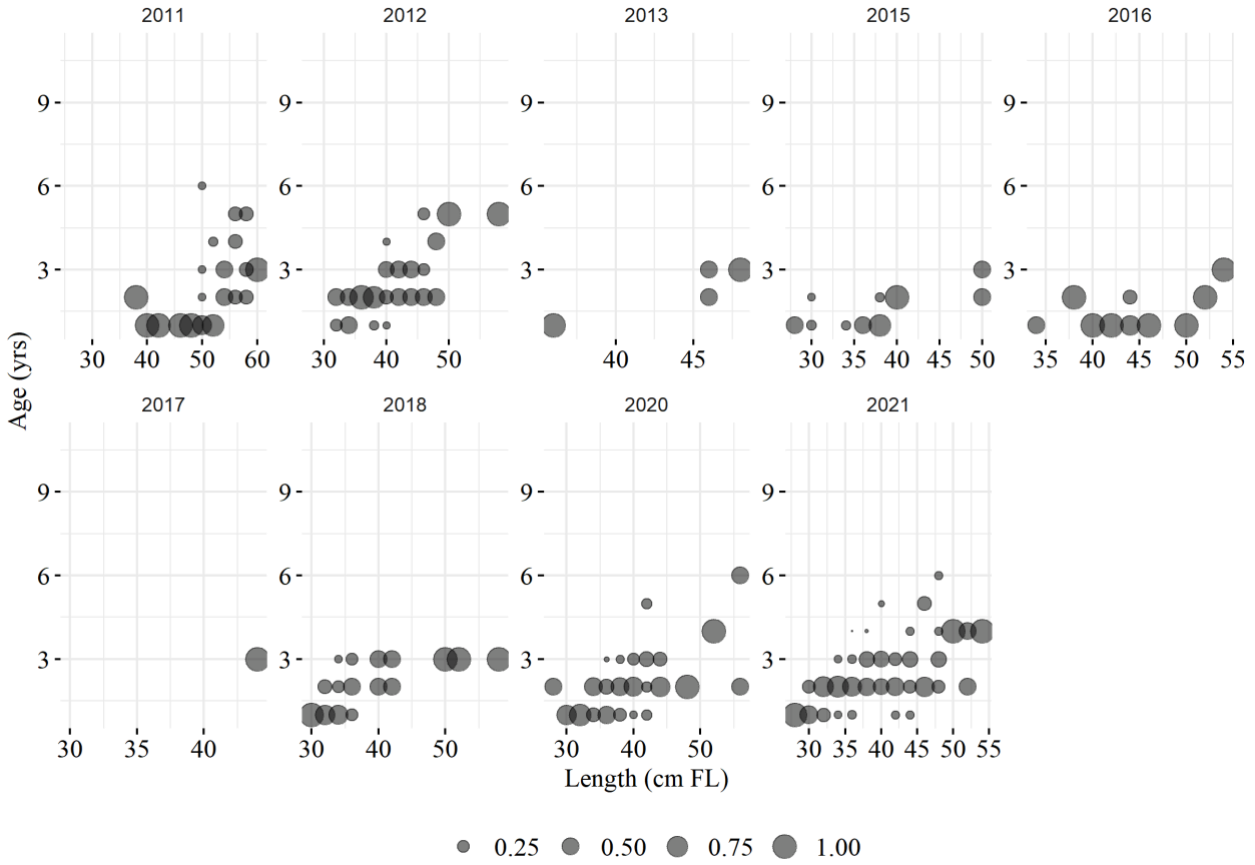

Figure 12: Annual Spanish Mackerel conditional age-at-length estimates from the recreational shore fleet.

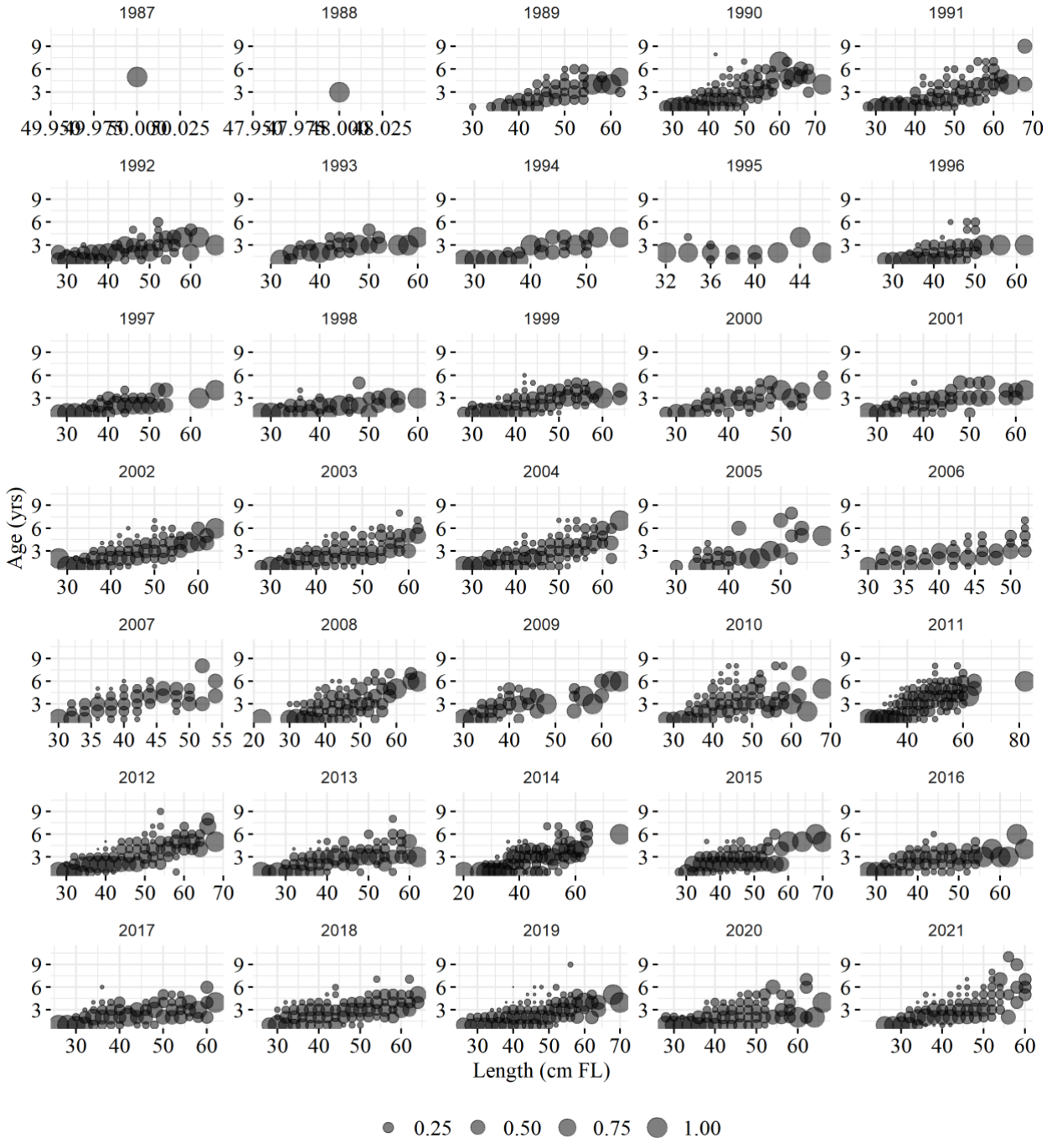

Figure 13: Annual Spanish Mackerel conditional age-at-length estimates from the recreational headboat/charter fleet.