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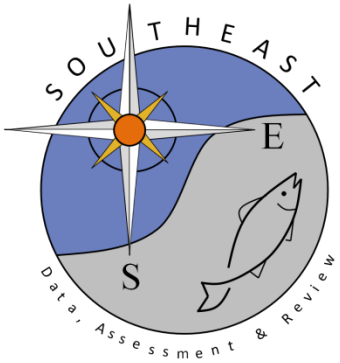

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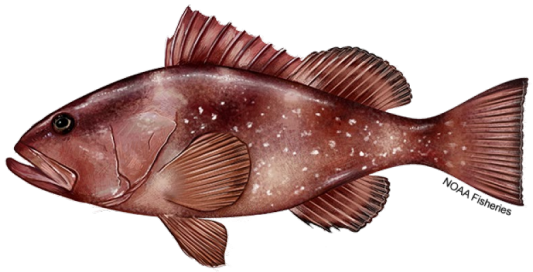

Gulf of Mexico Red Grouper (*Epinephelus morio*) Commercial Landings Length and Age Compositions

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†Submission was updated to fix several formatting errors that occurred when converting from word doc to pdf – content is not significantly different from original submission.

Introduction

This document outlines the data and methodologies used to estimate length and age compositions of commercial landings for the SEDAR 88 Gulf of Mexico Red Grouper Assessment. These compositions were estimated using data sources approved in SEDAR 61 combined with improved methodologies. 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 commercial fleets were weighted by their respective landings at the finest spatial and temporal scale available without losing data. The resultant weighted length compositions were then used to weight the age compositions as lengths are more heavily sampled and provide a clearer picture of the size distribution. Additionally, 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). Resulting analyses, data limitations, and research recommendations are discussed below.

Data Description

SEDAR 88 assesses all Gulf of Mexico Red Grouper extending northward from the Texas/Mexico border and eastward to the Florida Keys US1 boundary. Commercial data sources utilized to generate length compositions include length samples from the Trip Interview Program (Beggerly et al. 2022) and landings data from the Accumulated Landings Systems from 1986 until state trip ticket programs came into effect (Atkinson and Pawluk 2024). Age estimates from the Gulf States Marine Fisheries Commission Fisheries Information Network (GulfFIN) were compiled by the SEFSC Panama City Laboratory alongside their age data.

Commercial fleets were defined by handline (HL), longline (LL), and Trap (TR) gears. These data were compiled using length bins of 2 centimeters (cm) following SEDAR 61. Total length (TL) was converted to fork length (FL) using the following conversion equation from SEDAR 42:

$$FL = 0.571 + 0.95 * TL$$

Since 1990, the commercial fisheries have had a minimum size limit of 20” (50.8cm) TL in Gulf federal waters. A minimum size limit of 18” (45.7 cm) TL was established in 1986 in Florida state waters, but had little perceived impact (SEDAR 42 report). Fish landings measuring less than 10 cm FL were deleted as these were assumed to be unit errors (e.g. fish recorded as 10 cm were likely 10”).

Commercial Length Compositions of Landings

Length Samples

Length samples of commercial landings were obtained from the TIP database maintained by the NMFS Southeast Fisheries Science Center (SEFSC) and were filtered to remove biases that include samples from pooled trips.

Length Compositions

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.

Each commercial fleet (handline, longline, trap) was modeled for the entire Gulf of Mexico region, with weighting done by aggregating to two subregions based on the NMFS areas fished shown in Figure 1: Northern (N: areas 6-11), and Southern (S: areas 1-5). Due to small sample sizes in early years, spatial stratification was only used for 2000 onward, while early years were provided as nominal compositions for handline and longline. For the trap fishery, sample sizes were too small in all years to allow for spatial weighting and thus the trap length composition is nominal. These gears were sufficiently distinct to remain separate fleets (Figure 2) and gear-specific annual compositions are shown in Figure 3. Length distributions were shown by fishing areas grouped by sub-region (N,S) for handline (Figure 4), longline (Figure 5), and trap (Figure 6). Sample sizes of commercial lengths (Table 1) and trips (Table 2) were provided for each strata (year & gear, or year, gear, and subregion) for each fleet. Strata with less than 30 length samples, or less than 10 trips are recommended to be dropped from further analyses.

Within each fleet, strata-specific nominal length compositions were estimated using length bins of 2 cm, where for each year i, length bin j, and stratum s

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

$n_{i,j,s}$ is the number of samples in year i, stratum s, and lower inclusive length bin j; $n_{i,s}$ is the number of samples in year i and stratum s; and $LC_{i,j,s}$ is the proportion of the total number of sampled fish in each year i and stratum s within each lower inclusive length bin j. While all data are provided to the analyst for transparency, it is our recommendation that strata with fewer than 30 lengths or 10 trips be excluded from the assessment model due to insufficient sample size, potentially leading to non-representative compositions. Strata that do not meet sample size requirements are not presented in figures, although they are provided to the analyst. Next, the strata-specific length compositions were weighted based on the distribution of the landings estimates among strata (e.g. for handline (HL) prior to 2000, all strata are HL, and therefore there is no weighting, while 2000 onward strata consist of HL_N and HL_S, and the strata-specific compositions are weighted by the landings in the Northern and Southern subregions).

Proportions of annual landings from each stratum, $p_{i,s}$, were used to weight the strata-specific length compositions, $LC_{i,j,s}$, which were then summed across strata s

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

resulting in the final weighted estimates of landings length compositions, $LC_{i,j}$. The proportion of landings, $p_{i,s}$, for each year i and stratum s are aggregated into time periods and shown in Table 3 (aggregation into time periods was done for confidentiality purposes). This procedure would down-weight, 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 handline (Figure 7), longline (Figure 8), and Trap (Figure 9).

Commercial Age Compositions of Landings

Age Samples

Commercial 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 commercial ages (Table 4) and commercial trips sampled for age (Table 5) were provided. Red Grouper maximum age was estimated to be 29 years, with a plus group for age 20 plus used in modeling.

Age compositions

Nominal age compositions were estimated for each commercial gear (HL, LL, TR) within each stratum. The process outlined below was applied to each fleet individually, and any strata with less than 10 age samples was recommended to be dropped. Nominal age compositions of landings were estimated for all gears using the following equation within each year i, age bin k, and strata s.

$$AC_{i,k,s} = \frac{a_{i,k,s}}{a_{i,s}}$$

$a_{i,k,s}$ is the number of age samples in year i, stratum s, and lower inclusive age bin k; $a_{i,s}$ is the number of age samples in year i and stratum s; and $AC_{i,k,s}$ is the proportion of the total number of sampled fish in each year i and stratum s within each lower inclusive age bin k. A minimum sample size threshold was recommended annually within each stratum, $AC_{i,s}$, where these were recommended to be dropped and excluded from further analyses if $a_{i,s} < 10$.

To account for potential sampling biases in the data, a re-weighting factor was estimated within year i, length bin j, and stratum s. The re-weighting factor, $RW_{i,j,s}$, corrects the composition of the age data (number of age samples in each length bin divided by the annual total) to more closely represent the final length composition of landings,

$$RW_{i,j,s} = \frac{LC_{i,j,s} * p_{i,s}}{a_{i,j,s}/a_{i,s}}$$

where $LC_{i,j,s} * p_{i,s}$ is the weighted length composition, $a_{i,j,s}$ is the number of age samples in year i, length bin j, and stratum s; and $a_{i,s}$ is the number of age samples in year i and stratum s. Under this methodology, if there were age samples $a_{i,j,s}$ not represented in $LC_{i,j,s}$, they were down-weighted to zero and effectively dropped from further analysis. The final commercial weighted age compositions were estimated as

$$AC_{i,k} = \sum_{j,s} \left(RW_{i,j,s} * \frac{a_{i,j,k,s}}{a_{i,s}} \right)$$

where all length bins j within an age class k were summed, then re-scaled to sum to 1 across each year. The re-weighting factor will up-weight ages from length bins that are less represented

in the age data than the length only data and will generate a more representative estimate of landings' age compositions. The distribution of lengths for the length only data, compared to the lengths from the age data are shown in figures 10 – 12, for handline, longline, and trap. Effects of the age composition weighting procedure are shown for handline (Figure 13), longline (Figure 14), and Trap (Figure 15). Final weighted age distributions for handline (Figure 16), longline (Figure 17), and trap (Figure 18) are also shown as bubble plots to better display cohorts.

Commercial Conditional Age-at-Length

Within each commercial fleet (handline, longline, trap) conditional age-at-length (CAAL) 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 (Figures 19, 20, and 21).

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.

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

Departures from Previous SEDAR

In the previous assessment (SEDAR 61) a different methodology was used for weighting the age compositions. Instead of weighting the length compositions by the landings in each subregion, nominal lengths were used to weight the nominal age compositions, after which the landings were used to combine the sub-regional weighted ages into a single age composition (Chih 2014). This is different from the current standard best practice in which length compositions are weighted by landings in each subregion, and then weighted lengths are used to weight the nominal age compositions; as such, the effects of this weighting scheme were compared to the standard method. The results of that comparison are shown in Figures 22 (HL) and 23 (LL). Due to the limited impact of the different weighting schemes on the estimated compositions, it was decided that for the current assessment, the standard "best practice" approach to weighting the lengths and ages would be used, and the weighted ages following the SEDAR 61 method would be provided for comparison.

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Tables

Table 1. *Annual number of Red Grouper commercial handline (HL), longline (LL), and trap (TR) length samples by spatial strata (N,S - or all GoM when not stratified). The length compositions resulting from these samples were recommended to be dropped from further analyses if n<30.*

Year	HL	HL_N	HL_S	LL	LL_N	LL_S	TR
1984	1,371	0	0	1,121	0	0	18
1985	1,048	0	0	1,693	0	0	1,644
1986	512	0	0	5,653	0	0	1,240
1987	1,085	0	0	2,559	0	0	757
1988	1,153	0	0	1,375	0	0	0
1989	596	0	0	1,658	0	0	330
1990	920	0	0	10,237	0	0	337
1991	1,730	0	0	12,413	0	0	391
1992	2,427	0	0	8,494	0	0	844
1993	2,390	0	0	9,261	0	0	442
1994	3,087	0	0	7,905	0	0	207
1995	3,261	0	0	11,108	0	0	342
1996	3,082	0	0	9,761	0	0	677
1997	2,401	0	0	13,641	0	0	1,522
1998	3,412	0	0	28,972	0	0	816
1999	6,706	0	0	44,221	0	0	1,883
2000	0	2,901	4,722	0	4,819	25,316	2,702
2001	0	3,609	3,333	0	3,514	16,502	3,963
2002	0	2,704	2,681	0	2,302	15,868	2,177
2003	0	1,556	1,372	0	1,382	12,301	1,342
2004	0	1,645	955	0	975	10,131	364
2005	0	716	356	0	1,520	6,034	205
2006	0	528	181	0	1,408	3,024	273
2007	0	903	90	0	506	2,273	0
2008	0	927	299	0	1,194	3,446	0
2009	0	2,429	1,315	0	358	2,102	0
2010	0	994	850	0	508	3,286	0
2011	0	3,773	1,284	0	1,474	3,342	0
2012	0	7,391	3,085	0	2,443	4,630	0
2013	0	5,905	3,355	0	1,527	5,571	0
2014	0	3,600	2,563	0	769	5,714	0
2015	0	1,783	2,955	0	868	3,396	0
2016	0	1,778	1,453	0	792	4,411	0
2017	0	1,716	1,071	0	767	3,269	0
2018	0	1,405	654	0	330	2,221	0
2019	0	1,339	1,286	0	560	1,632	0
2020	0	1,508	1,156	0	198	1,074	0
2021	0	1,655	764	0	503	823	12
2022	0	1,832	765	0	1,748	2,526	0

Table 2. *Annual number of Red Grouper commercial handline (HL), longline (LL), and Trap (TR) trips sampled for lengths by spatial strata (N,S - or all GoM when not stratified).*

Year	HL	HL_N	HL_S	LL	LL_N	LL_S	TR
1984	40	0	0	18	0	0	1
1985	41	0	0	38	0	0	6
1986	23	0	0	113	0	0	10
1987	42	0	0	47	0	0	5
1988	21	0	0	21	0	0	0
1989	8	0	0	21	0	0	3
1990	41	0	0	75	0	0	13
1991	58	0	0	88	0	0	8
1992	77	0	0	89	0	0	14
1993	103	0	0	112	0	0	12
1994	114	0	0	134	0	0	4
1995	131	0	0	141	0	0	6
1996	144	0	0	118	0	0	14
1997	112	0	0	163	0	0	23
1998	161	0	0	288	0	0	23
1999	182	0	0	337	0	0	20
2000	0	82	97	0	53	224	39
2001	0	100	102	0	68	182	47
2002	0	105	89	0	75	200	36
2003	0	117	74	0	76	264	22
2004	0	105	46	0	54	230	5
2005	0	64	38	0	75	220	4
2006	0	58	34	0	67	220	12
2007	0	67	19	0	36	191	0
2008	0	75	36	0	73	204	0
2009	0	144	99	0	20	114	0
2010	0	74	77	0	32	178	0
2011	0	255	102	0	51	148	0
2012	0	391	126	0	43	145	0
2013	0	345	139	0	47	150	0
2014	0	248	132	0	23	153	0
2015	0	213	150	0	22	138	0
2016	0	256	91	0	24	168	0
2017	0	194	86	0	29	130	0
2018	0	213	81	0	25	108	0
2019	0	216	140	0	27	102	0
2020	0	216	98	0	7	46	0
2021	0	119	49	0	12	43	1
2022	0	234	111	0	43	134	0

Table 3. *Distribution of commercial handline (HL), longline (LL), and trap (TR) landings by fleet, subregion, and time interval.*

Management Period	HL_N	HL_S	LL_N	LL_S	TR_N	TR_S
1986-2009	0.50	0.50	0.21	0.79	0.44	0.56
2010-2022	0.41	0.59	0.16	0.84	1.00	

Table 4. *Annual number of commercial handline (HL), longline (LL), and trap (TR) age samples by spatial strata (N,S - or all GoM when not stratified).*

Year	HL	HL_N	HL_S	LL	LL_N	LL_S	TR
1981	212	0	0	0	0	0	0
1991	43	0	0	37	0	0	2
1992	42	0	0	141	0	0	14
1993	93	0	0	200	0	0	84
1994	238	0	0	88	0	0	29
1995	180	0	0	140	0	0	39
1996	86	0	0	96	0	0	8
1997	35	0	0	7	0	0	17
1998	39	0	0	122	0	0	33
1999	77	0	0	643	0	0	31
2000	0	144	62	0	137	268	38
2001	0	370	211	0	880	342	40
2002	0	154	417	0	607	460	89
2003	0	305	247	0	234	846	65
2004	0	528	526	0	200	914	36
2005	0	397	228	0	269	1,187	0
2006	0	299	330	0	157	375	173
2007	0	435	61	0	144	452	0
2008	0	375	126	0	143	366	0
2009	0	383	125	0	86	592	0
2010	0	344	170	0	234	925	0
2011	0	377	135	0	160	453	0
2012	0	571	267	0	192	836	0
2013	0	387	136	0	276	896	0
2014	0	404	146	0	158	848	0
2015	0	417	332	0	130	457	0
2016	0	384	150	0	150	500	0
2017	0	376	155	0	131	398	0
2018	0	185	275	0	49	463	0
2019	0	174	327	0	64	506	0
2020	0	158	347	0	43	485	0
2021	0	171	332	0	49	406	12
2022	0	181	301	0	49	471	0

Table 5. *Annual number of commercial handline (HL), longline (LL), and trap (TR) trips sampled for ages by spatial strata (N,S - or all GoM when not stratified).*

Year	HL	HL_N	HL_S	LL	LL_N	LL_S	TR
1981	33	0	0	0	0	0	0
1991	16	0	0	3	0	0	1
1992	11	0	0	8	0	0	1
1993	30	0	0	16	0	0	6
1994	30	0	0	12	0	0	2
1995	34	0	0	19	0	0	2
1996	17	0	0	11	0	0	1
1997	6	0	0	1	0	0	1
1998	10	0	0	17	0	0	4
1999	18	0	0	69	0	0	3
2000	0	16	11	0	10	26	4
2001	0	31	33	0	40	50	4
2002	0	28	39	0	59	86	11
2003	0	66	43	0	54	124	5
2004	0	65	58	0	45	148	2
2005	0	39	33	0	32	132	0
2006	0	41	46	0	46	133	8
2007	0	68	16	0	42	143	0
2008	0	36	13	0	25	69	0
2009	0	105	57	0	15	74	0
2010	0	53	62	0	31	153	0
2011	0	169	57	0	35	114	0
2012	0	304	121	0	54	219	0
2013	0	201	65	0	85	285	0
2014	0	164	77	0	28	257	0
2015	0	163	190	0	22	124	0
2016	0	146	63	0	28	146	0
2017	0	133	58	0	27	112	0
2018	0	109	73	0	19	104	0
2019	0	110	126	0	32	114	0
2020	0	99	97	0	7	44	0
2021	0	87	43	0	11	43	1
2022	0	111	82	0	28	116	0

Figures

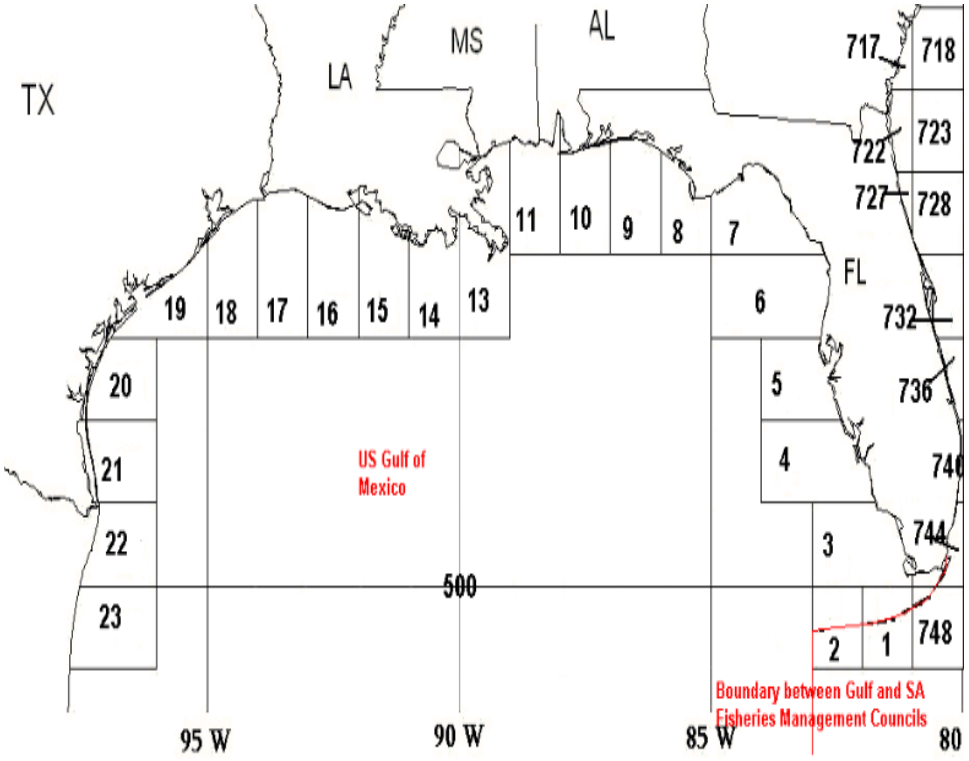

Figure 1. *NMFS commercial fishing areas in the Gulf of Mexico used to define stock boundaries.*

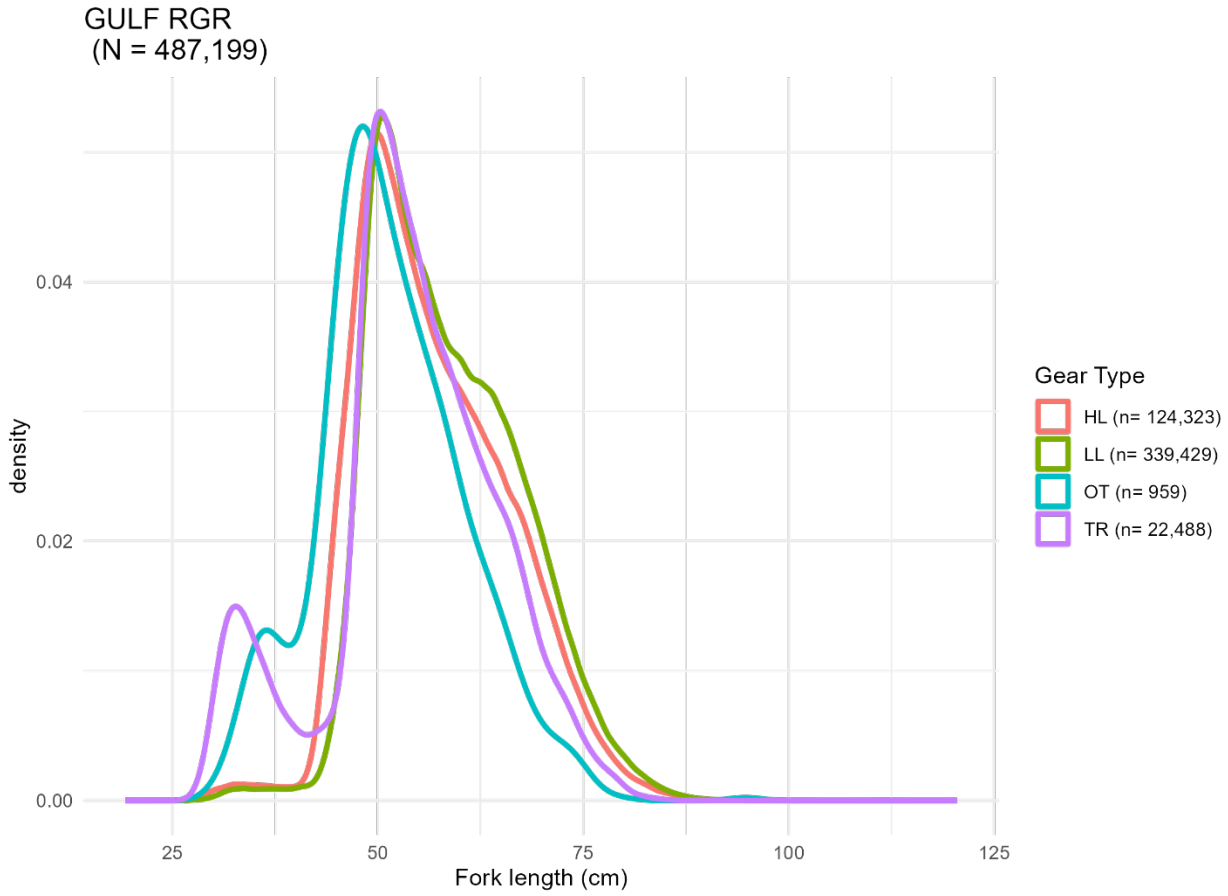

Figure 2. *Annually and spatially aggregated commercial gear length distributions: Handline (HL), longline (LL), trap (TR), and other (OT) gears.*

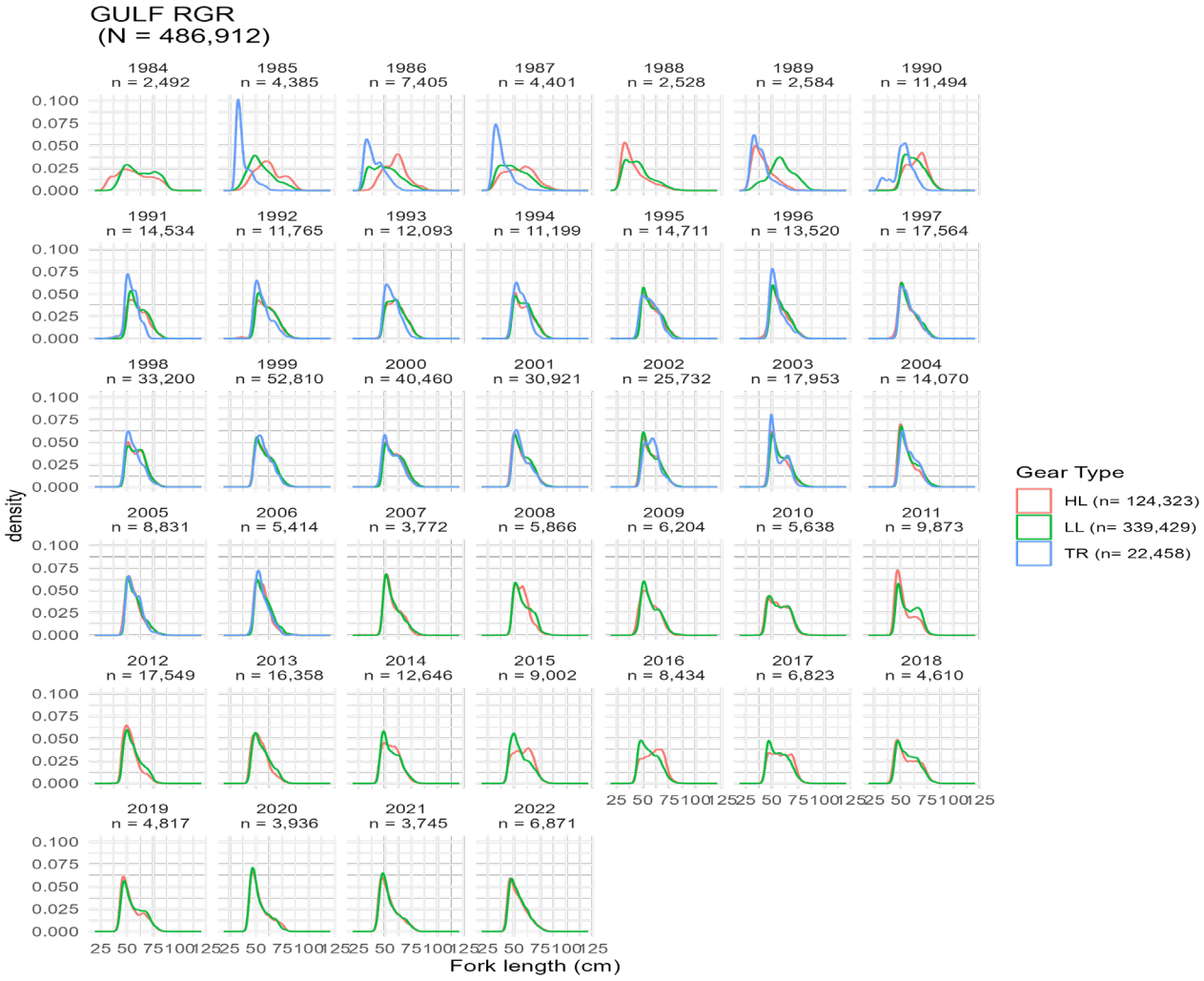

Figure 3. *Spatially aggregated Red Grouper commercial gear cumulative length distributions: handline (HL), longline (LL), and trap (TR) gears. Strata with less than 30 samples were dropped.*

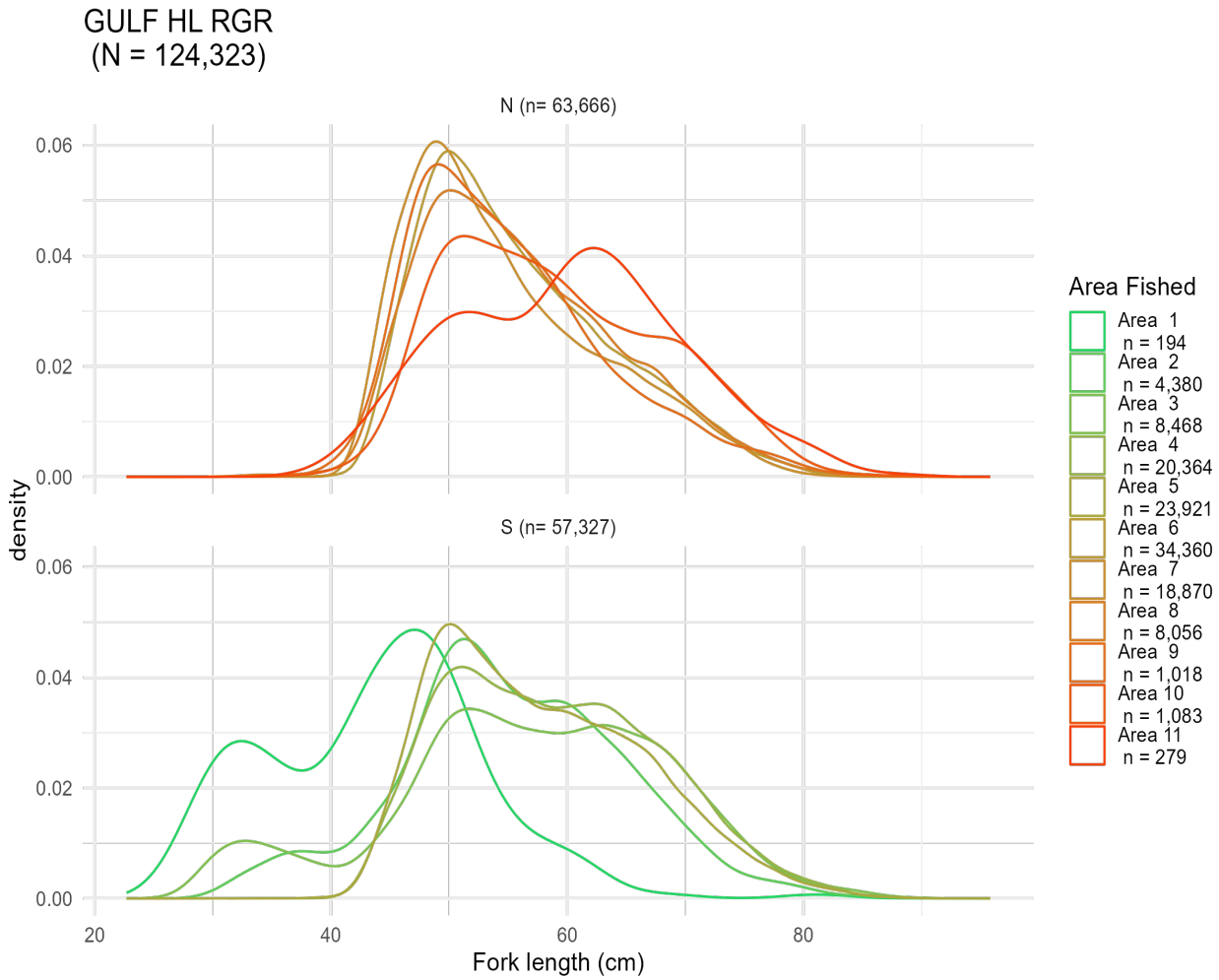

Figure 4. *Annually aggregated Red Grouper commercial handline length distributions by area fished for each subregion: Northern (N: 6-11), and Southern (S: 1-5).*

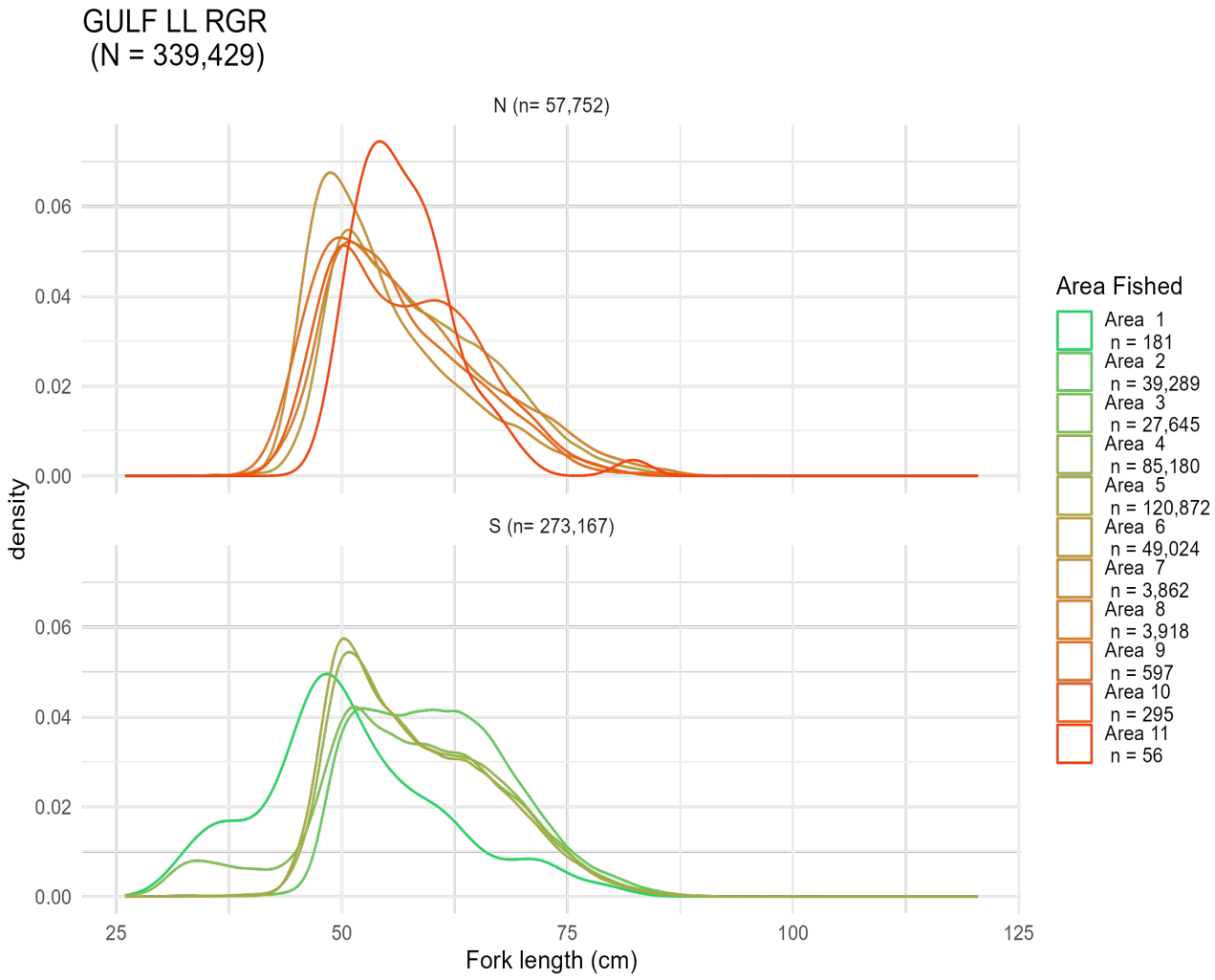

Figure 5. *Annually aggregated Red Grouper commercial longline length distributions by area fished for each subregion: Northern (N: 6-11), and Southern (S: 1-5).*

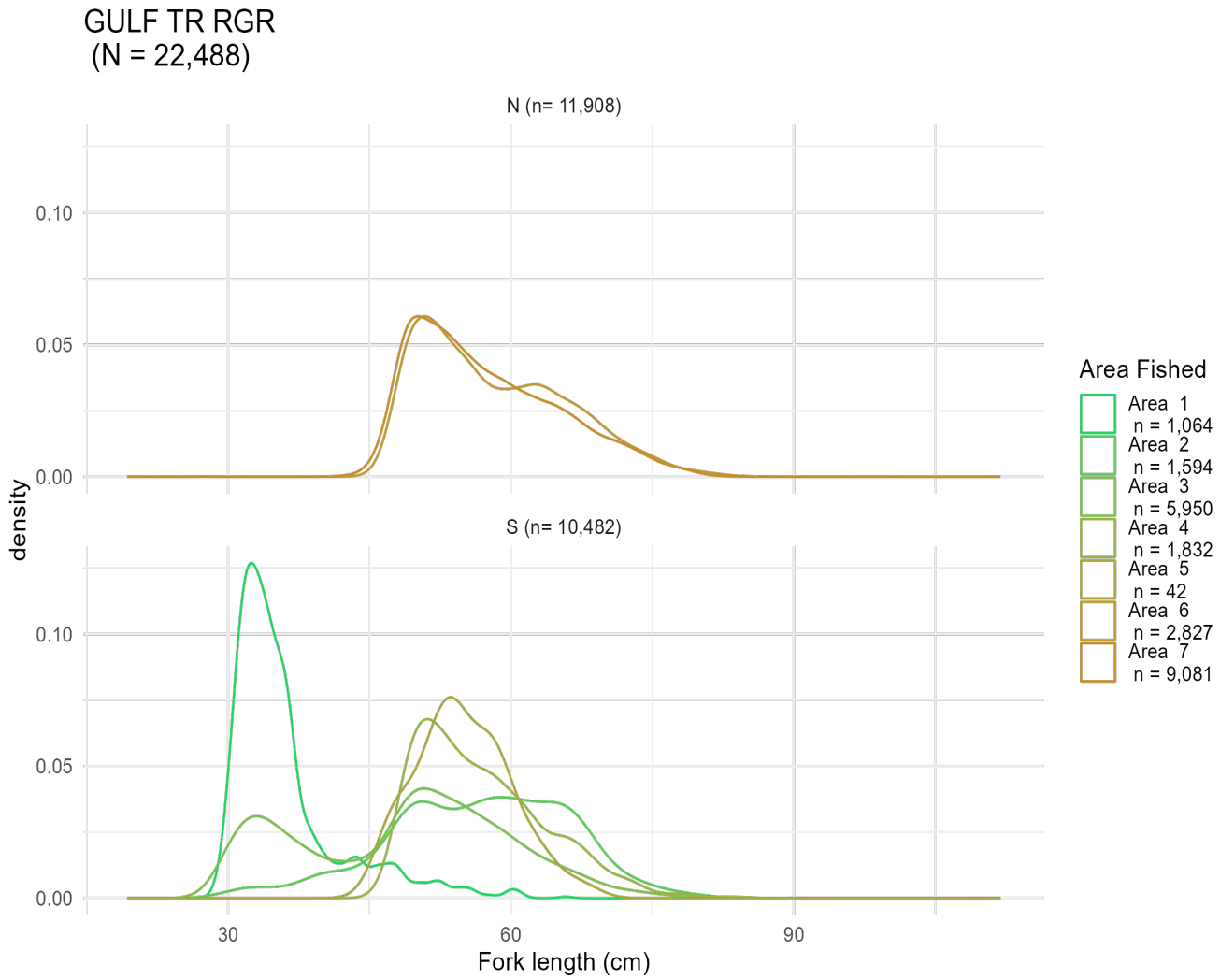

Figure 6. *Annually aggregated Red Grouper commercial trap length distributions by area fished for each subregion: Northern (N: 6-11), and Southern (S: 1-5).*

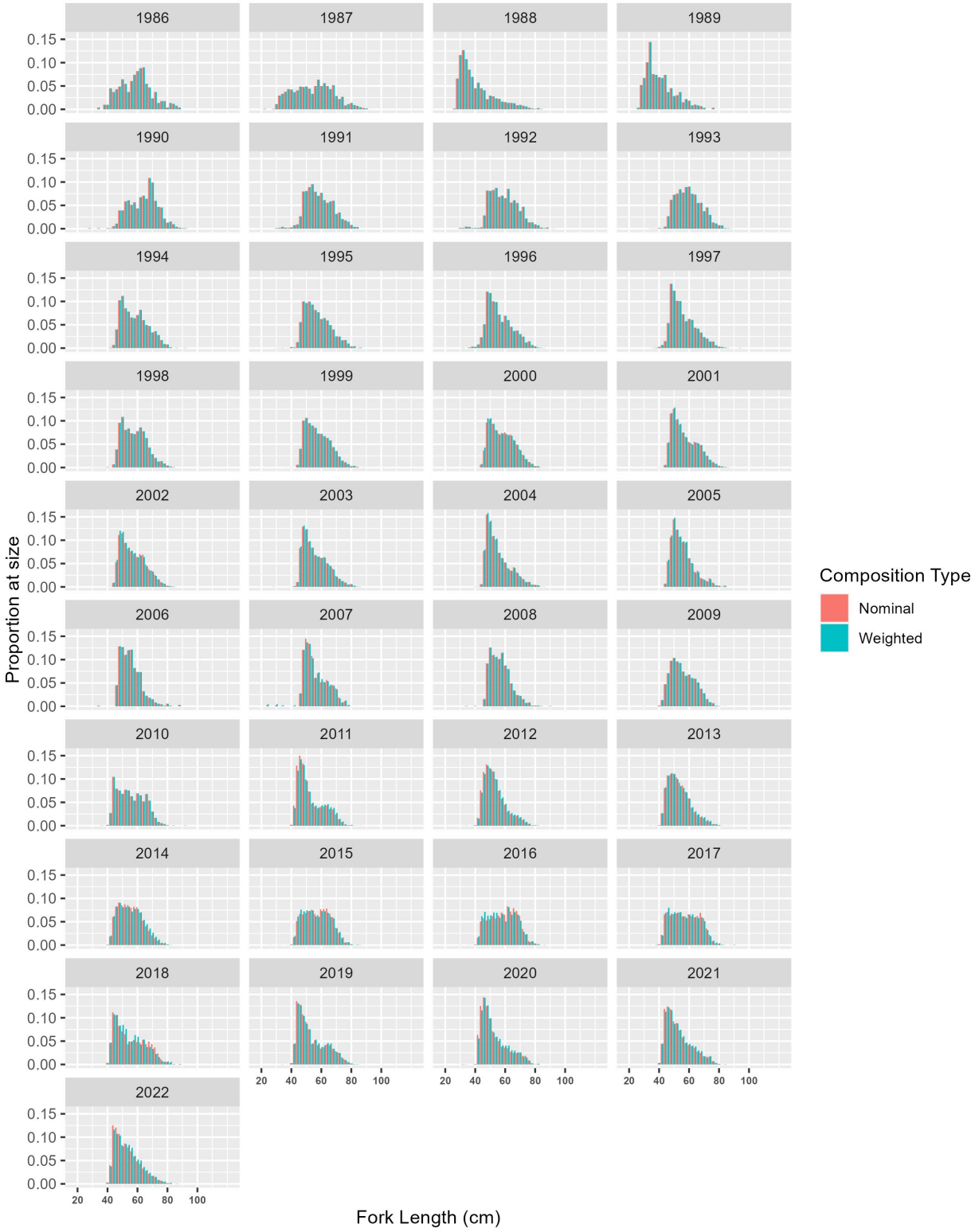

Figure 7. *Nominal and weighted Red Grouper length compositions from the commercial handline fleet.*

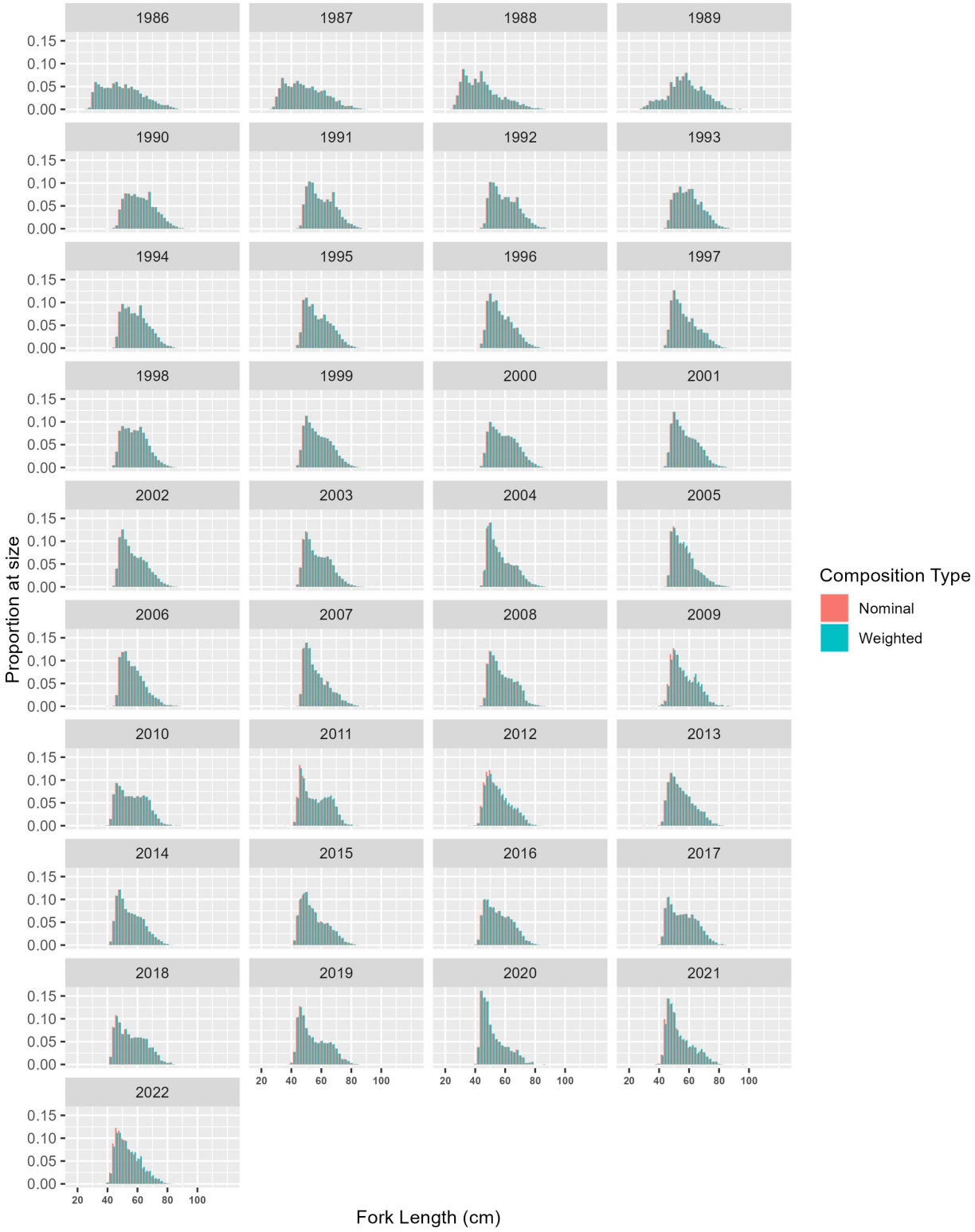

Figure 8. *Nominal and weighted Red Grouper length compositions from the commercial longline fleet.*

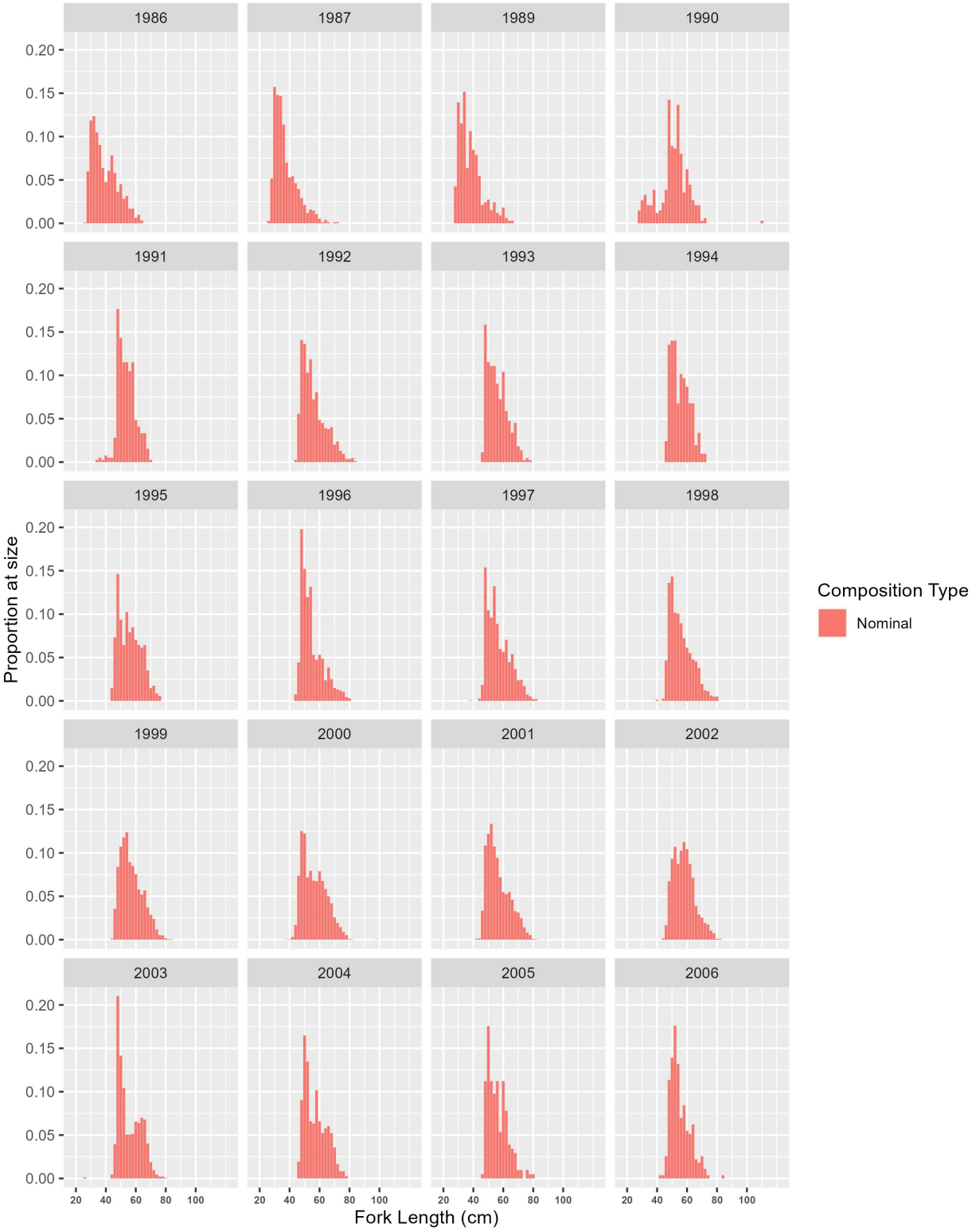

Figure 9. *Nominal Red Grouper length compositions from the commercial trap fleet. *Note, no weighting done for trap lengths, therefore only Nominal lengths presented.*

Figure 10. *Annual comparison of Red Grouper length distributions for the length only data compared to the age data for the commercial handline fishery.*

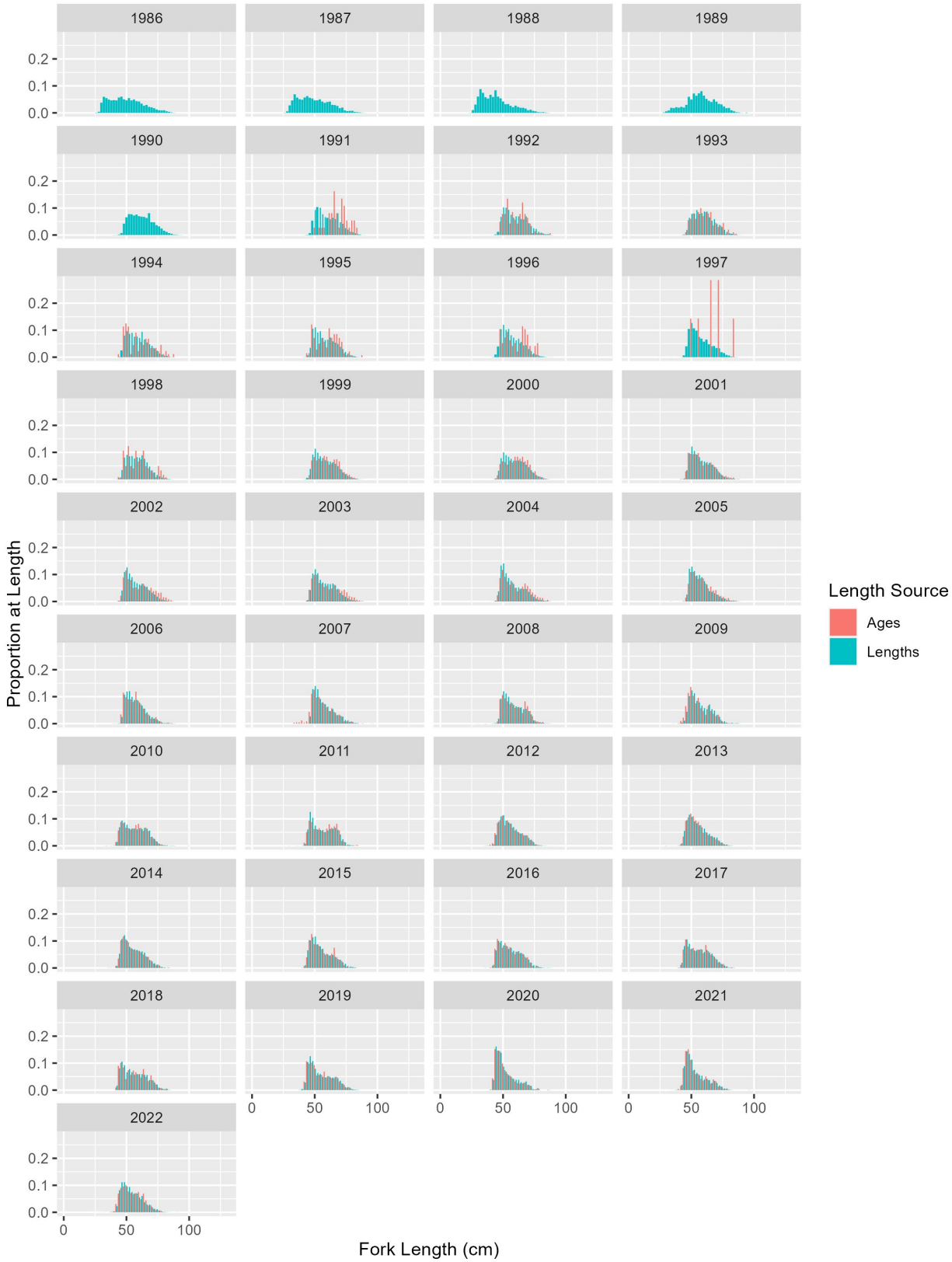

Figure 11. *Annual comparison of Red Grouper length distributions for the length only data compared to the age data for the commercial longline fishery.*

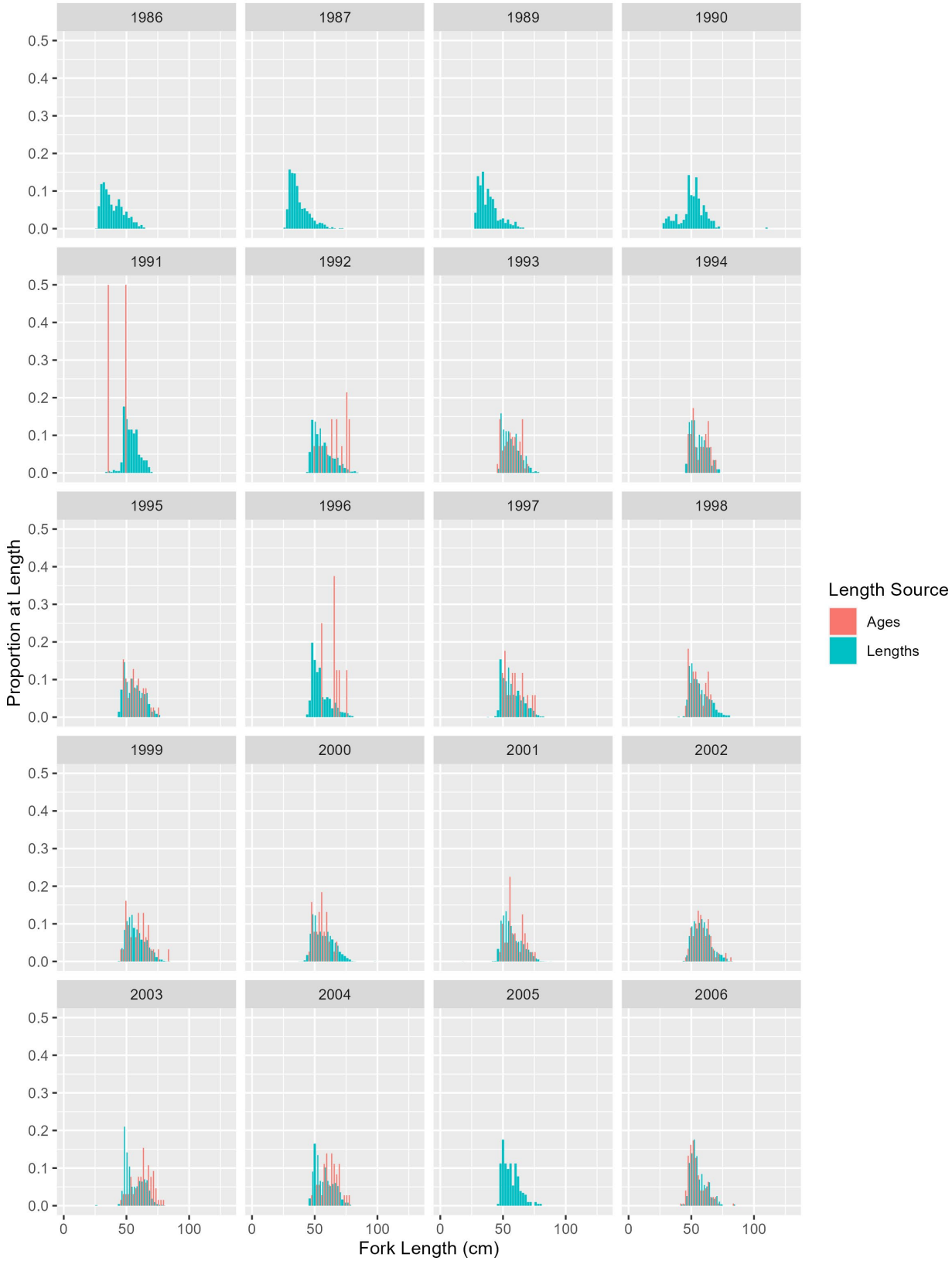

Figure 12. *Annual comparison of Red Grouper length distributions for the length only data compared to the age data for the commercial handline fishery.*

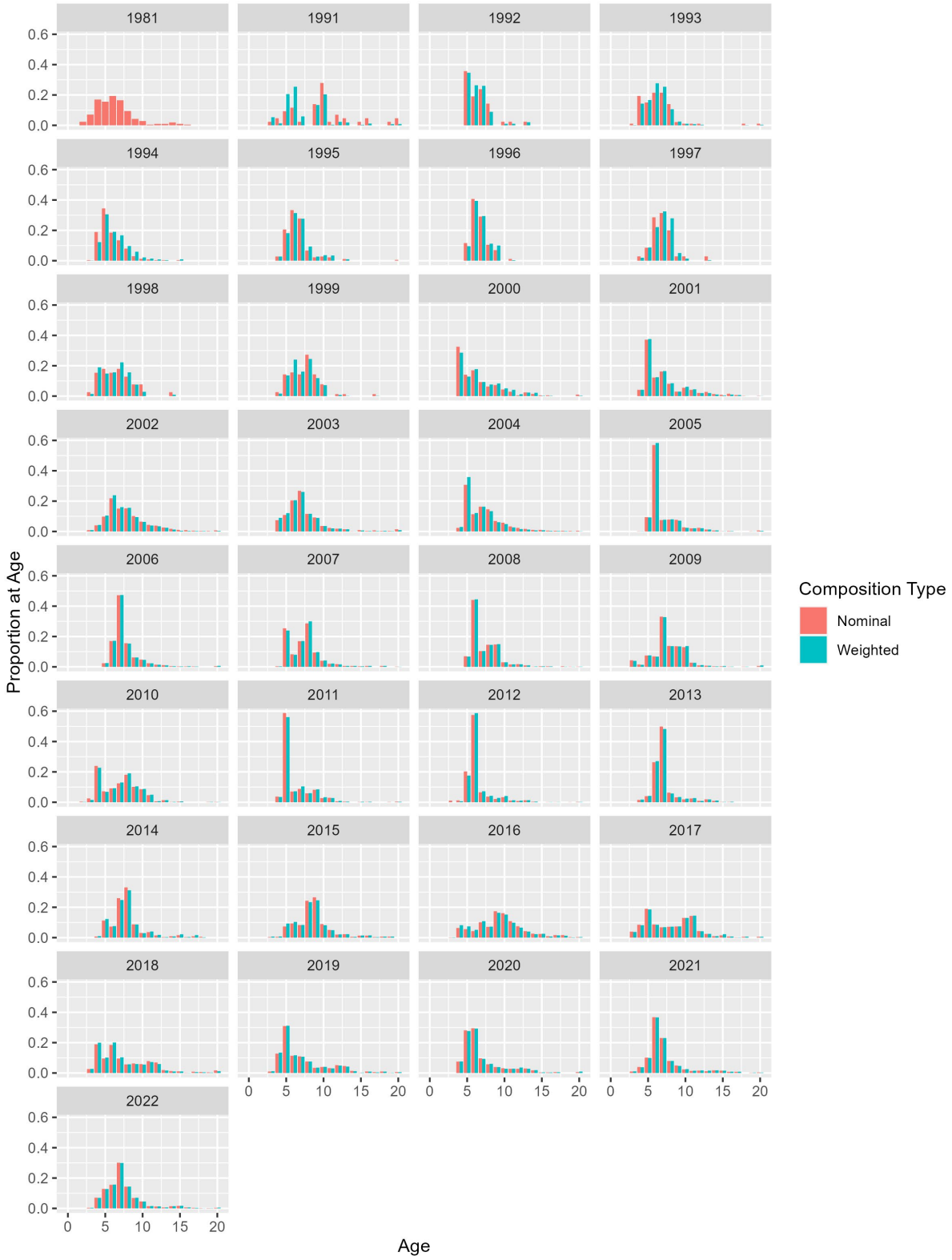

Figure 13. *Nominal and weighted Red Grouper age compositions from the commercial handline fleet.*

Figure 14. *Nominal and weighted Red Grouper age compositions from the commercial longline fleet.*

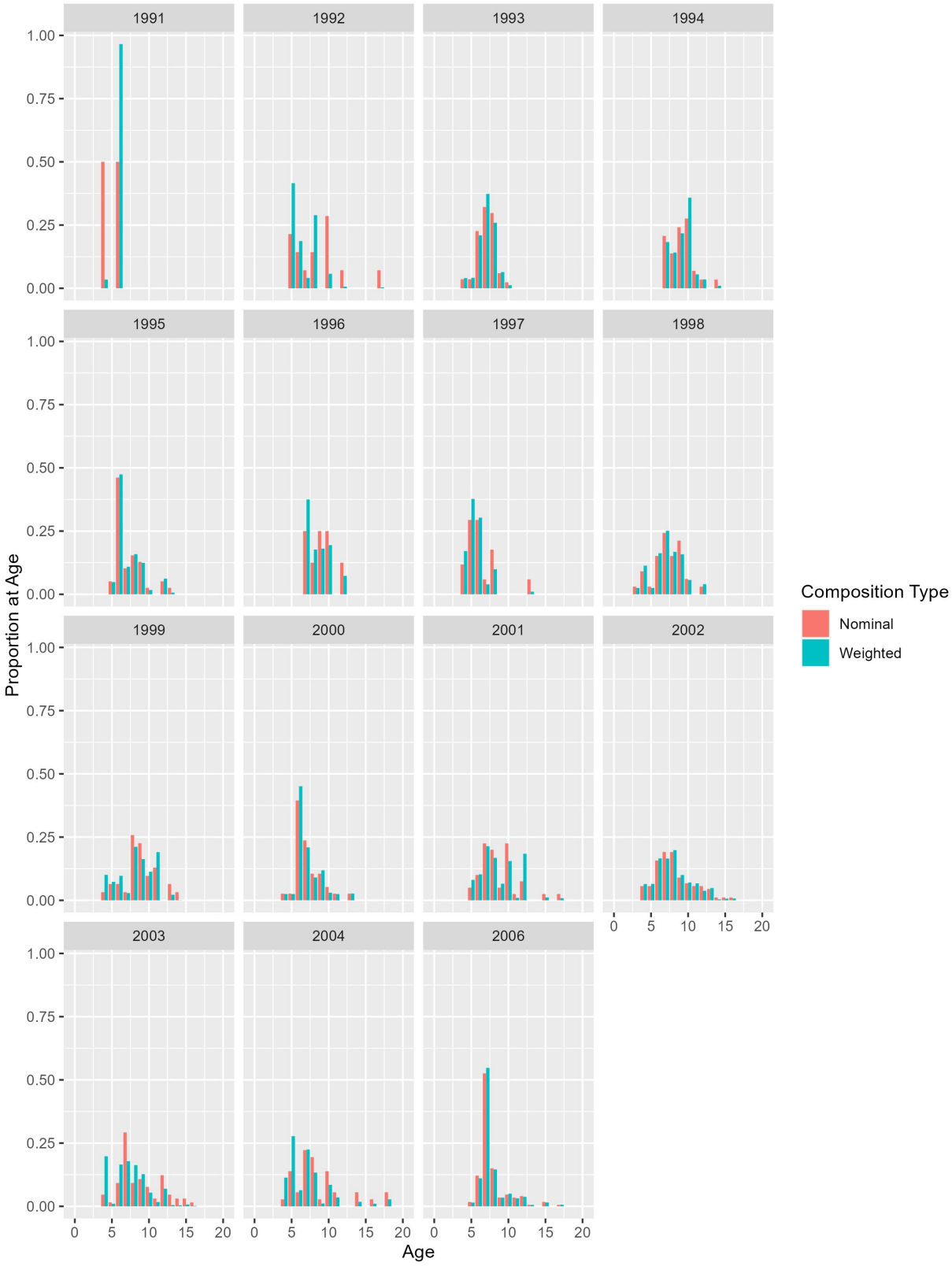

Figure 15. *Nominal and weighted Red Grouper age compositions from the commercial trap fleet.*

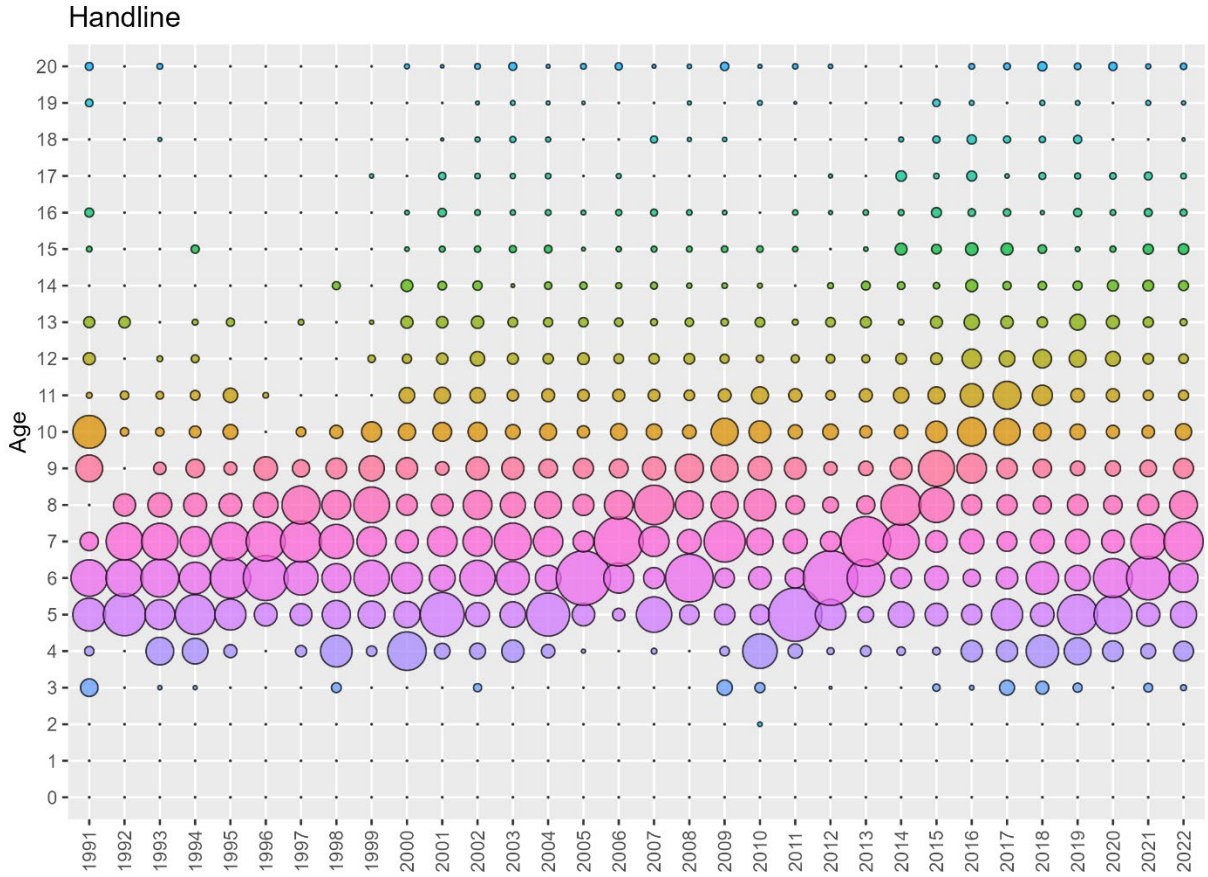

Figure 16. *Final annual weighted age compositions for the Red Grouper commercial handline fishery. The size of the dots represents the relative proportion at age.*

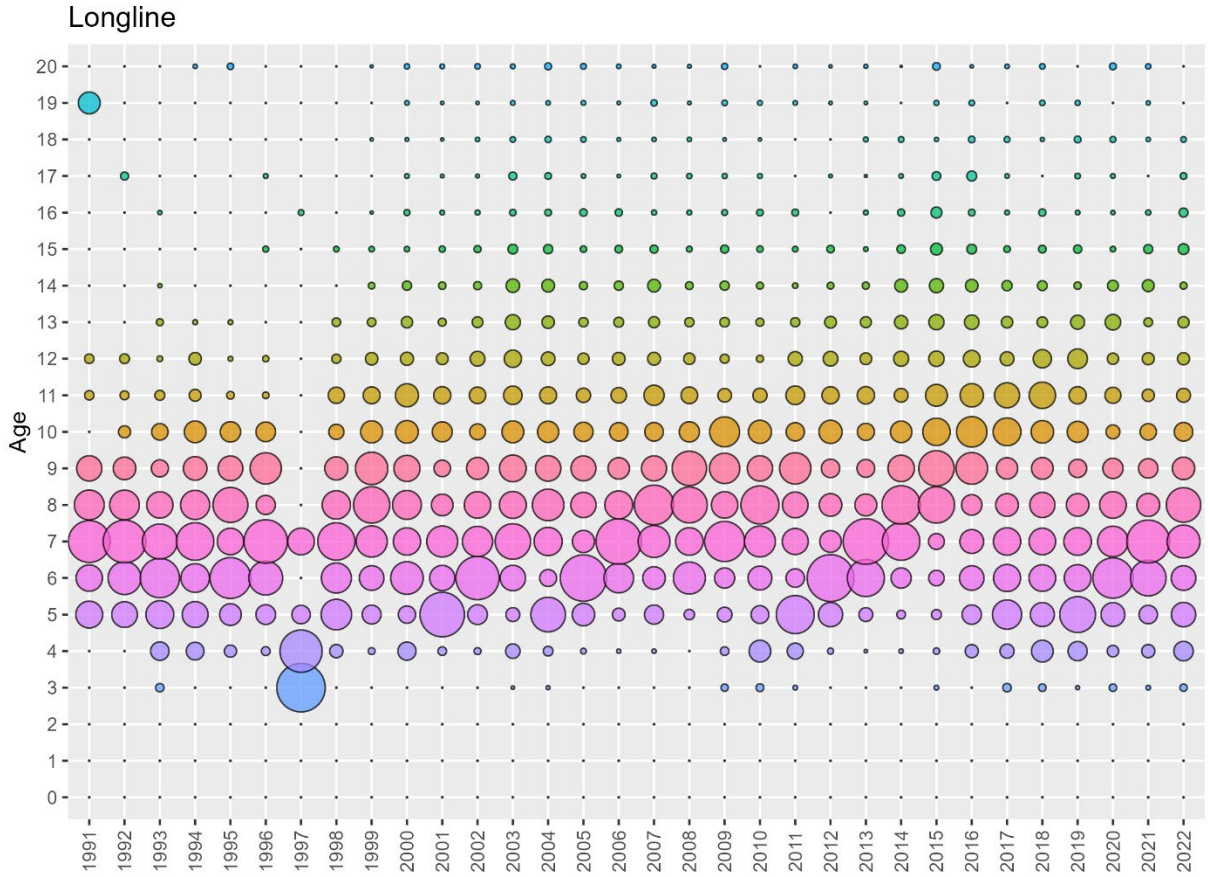

Figure 17. *Final annual weighted age compositions for the Red Grouper commercial longline fishery. The size of the dots represents the relative proportion at age.*

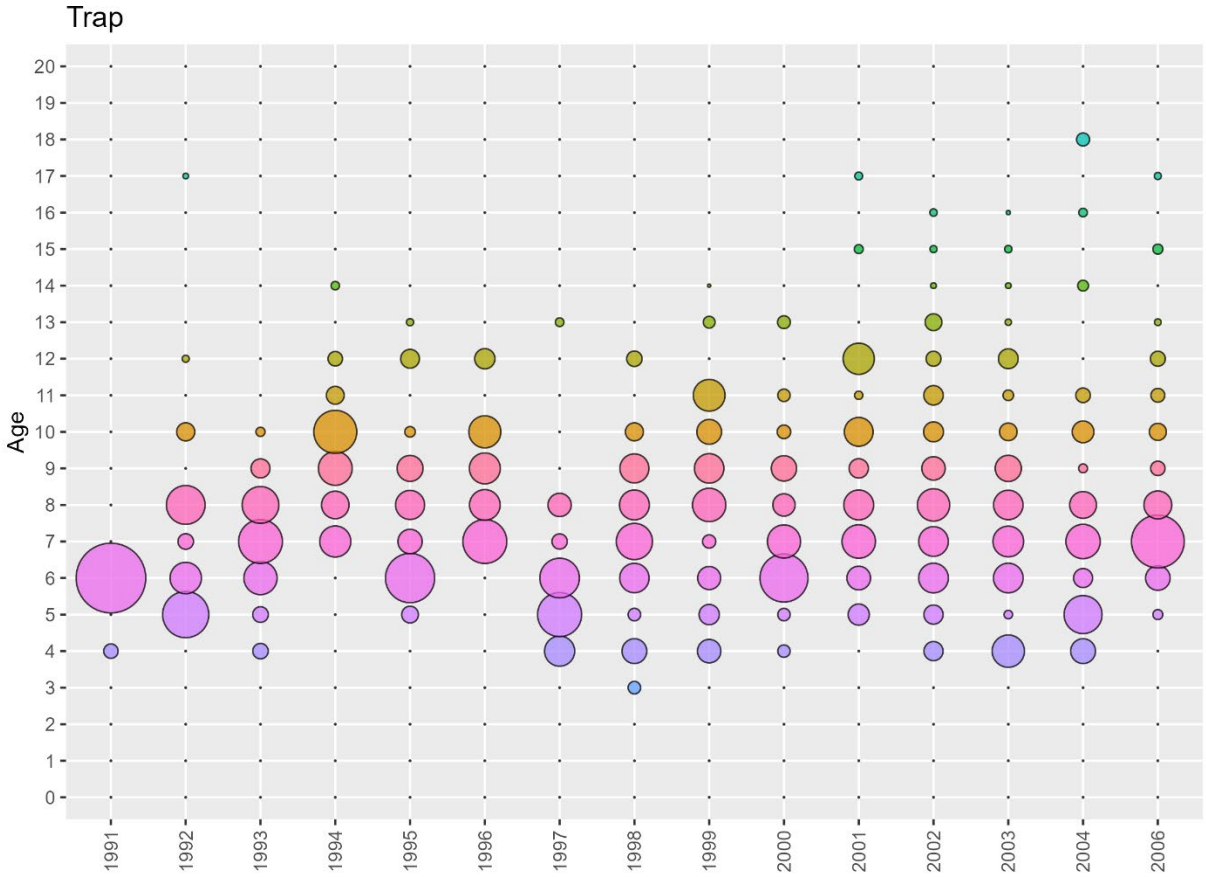

Figure 18. *Final annual weighted age compositions for the Red Grouper commercial trap fishery. The size of the dots represents the relative proportion at age.*

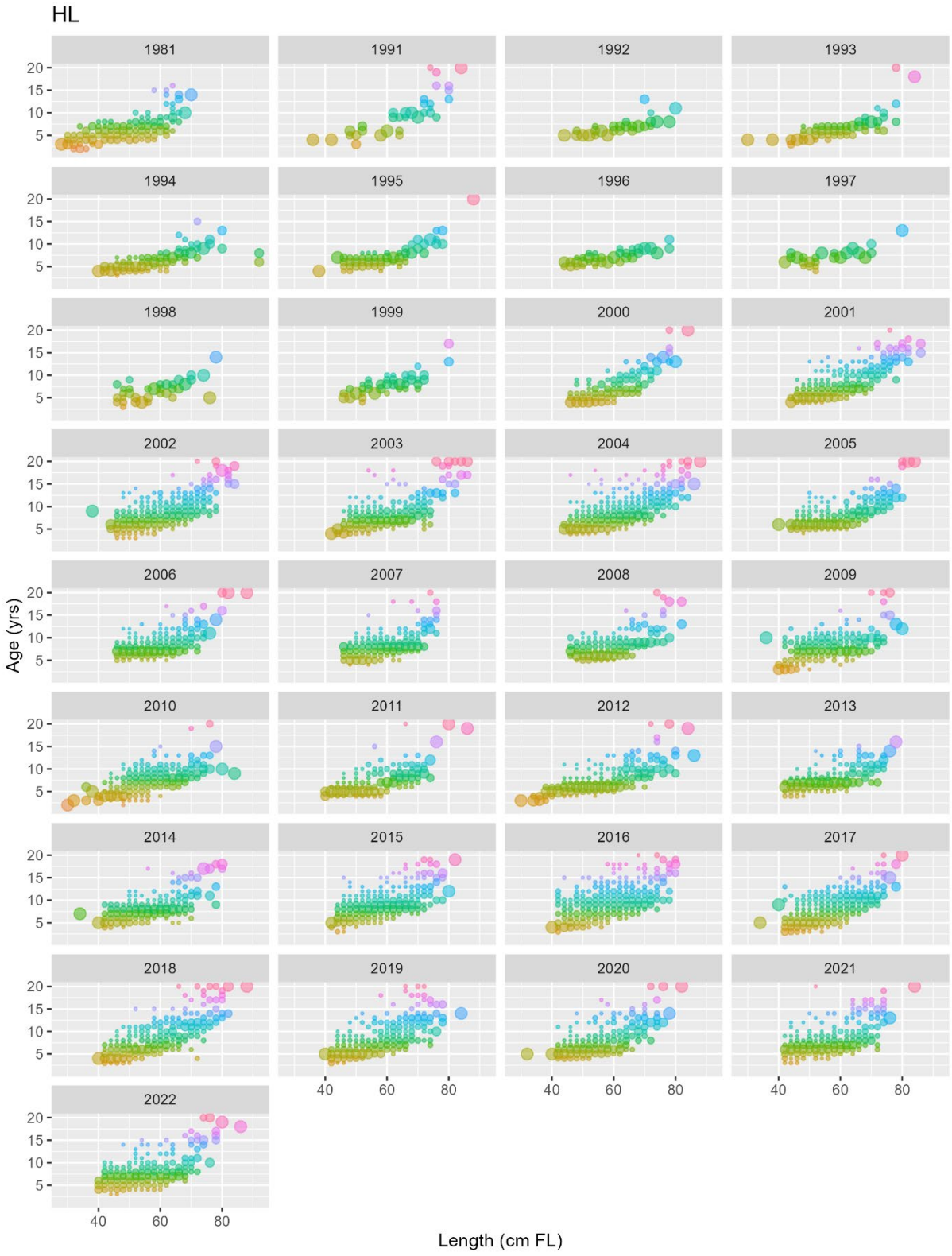

Figure 19. *Annual Red Grouper conditional age-at-length estimates from the commercial handline fleet.*

Figure 20. *Annual Red Grouper conditional age-at-length estimates from the commercial longline fleet.*

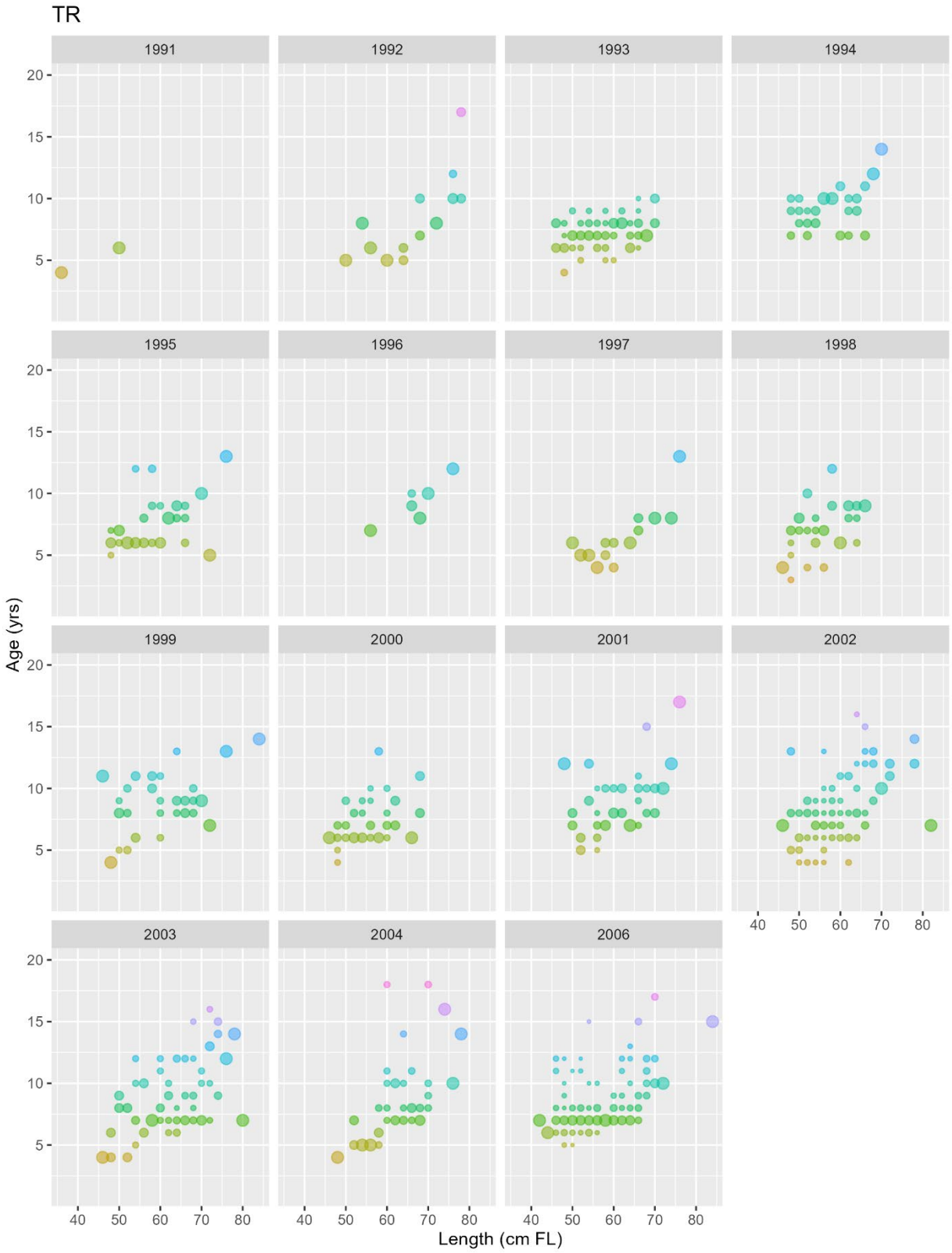

Figure 21. *Annual Red Grouper conditional age-at-length estimates from the commercial trap fleet.*

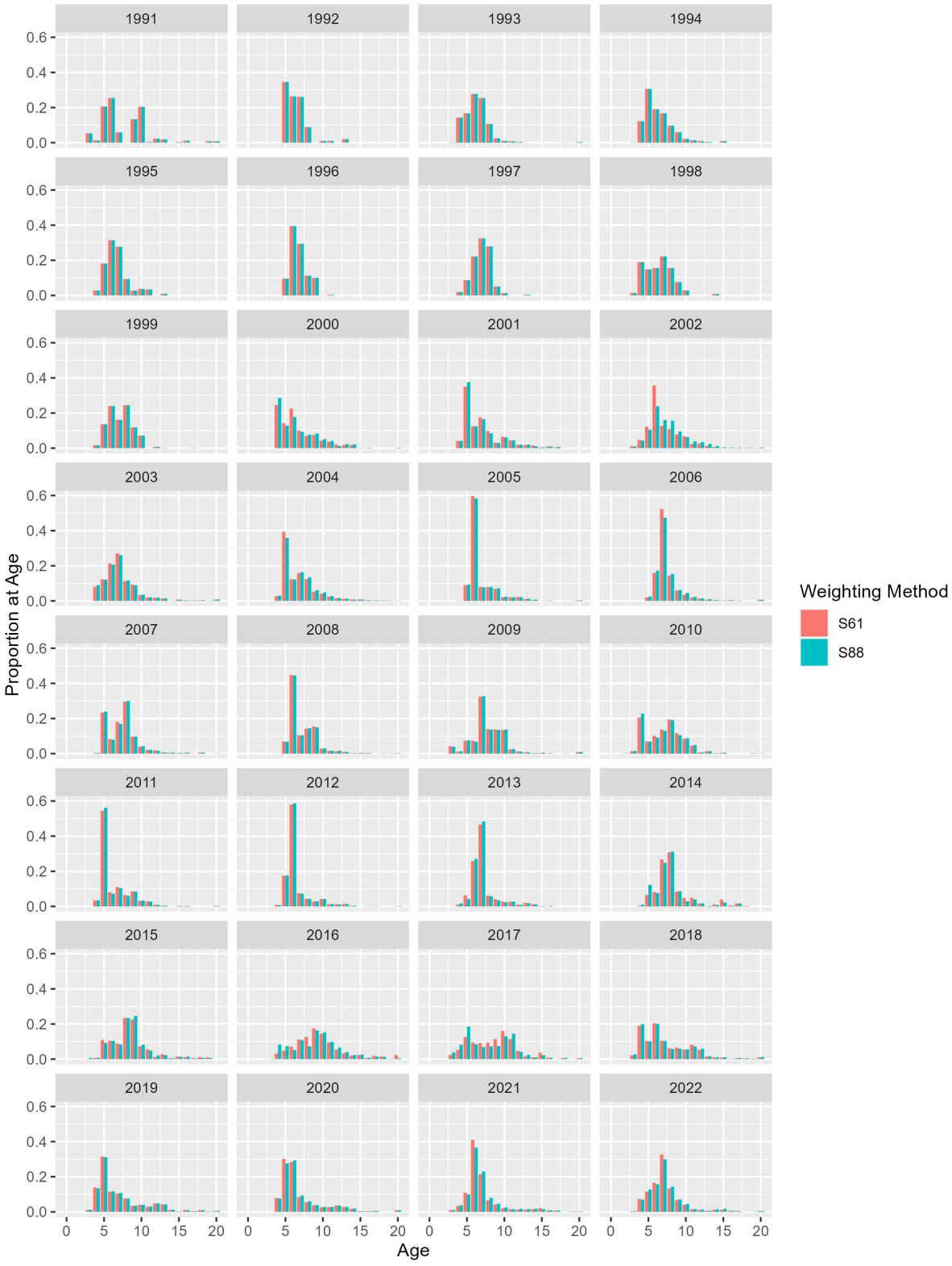

Figure 22. *Annual Red Grouper weighted age compositions from the commercial handline fleet using the differing weighting approaches for SEDAR 61 and SEDAR 88.*

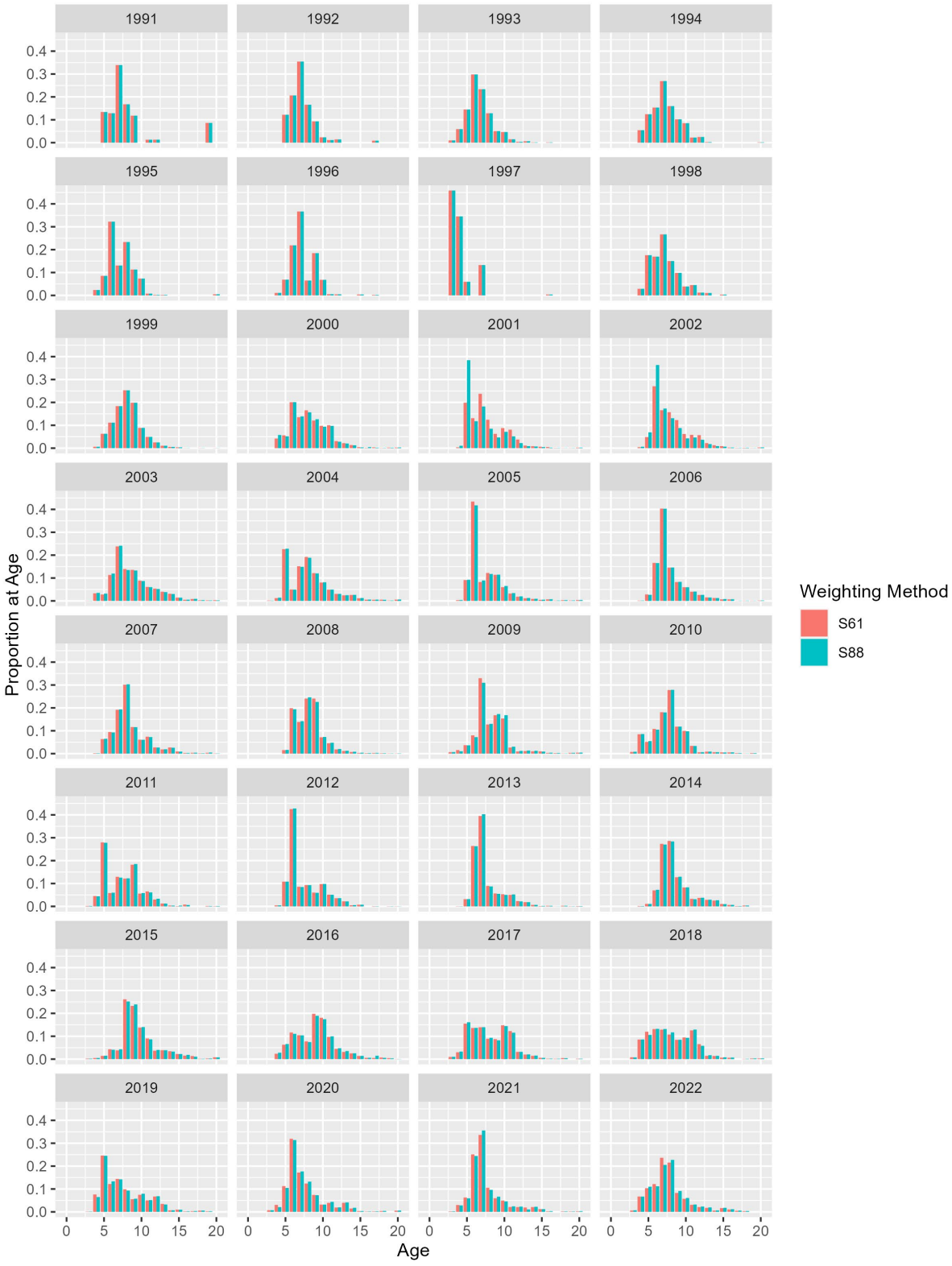

Figure 23. *Annual Red Grouper weighted age compositions from the commercial longline fleet using the differing weighting approaches for SEDAR 61 and SEDAR 88.*