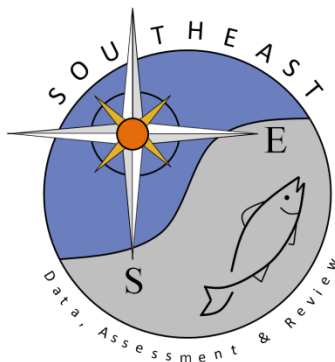


Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of Mexico

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Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of Mexico

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Introduction

Red groupers were treated as a single stock in the previous stock assessment. However, a previous study by Lombardi-Carlson et al. (2008) showed that, for otolith samples collected from commercial red grouper fisheries from 2000 to 2005, distinct differences in growth patterns and age frequency distributions (AFDs) occurred between the northern and southern regions (separated at 28° N latitude) of the Gulf of Mexico. The observed spatial differences in growth parameters and lengths-at-age in Lombardi-Carlson's study could be due to various factors including differences in growth, size related movement or selectivity, or sampling practices in different areas.

The age-length-key sampling method, which samples a fixed number of otolith samples from different length intervals, is known to affect the estimation of growth parameters and lengths-at-age (Chih, 2009). Otolith samples collected from commercial fisheries for the Trip Interview Program (TIP), particularly those samples collected before 2004, may have used the age-length-key sampling method (Chih, 2006). As a result, age frequency distributions, lengths-at-age or growth parameters estimated directly from those otolith samples used in Lombardi-Carlson et al.'s study may not have been representative of the population from which these samples were collected. However, the observed changes in AFDs in their study require further investigation so that the mechanism(s) of these changes in AFDs may be understood.

The present study focuses on the changes in length frequency distributions (LFDs) estimated from length samples, which were randomly selected from commercial fisheries, and changes in age-at-length (i.e., age length keys- ALK), which is not influenced by the otolith sampling method used. The primary goals for this study were: (a) to examine if there were gradual changes in LFDs/AFDs/ALKs along the west coast of Florida, (b) to evaluate if red grouper age samples, which were subsamples of length samples, were randomly selected, and (c) to identify whether the observed increases in the proportion of larger and older fish in the southern Gulf of Mexico were due to changes in age or size related movement or selectivity. Red grouper samples collected from commercial fisheries were used in this study. Red grouper samples from recreational fisheries were not used due to small sample sizes.

Materials and Methods

Length samples from commercial fisheries were obtained from the TIP database housed at the Southeast Fisheries Science Center (SEFSC). Age samples were processed and read by the Panama City Laboratory, SEFSC.

Changes in LFDs/AFDs/ALKs were analyzed for different fishing areas by grid. Samples collected from 2000 to 2013 were combined so that the sample sizes were large enough to identify the general trends of changes in LFDs/AFDs/ALKs for different fishing areas. For changes in LFDs/ALKs in individual years, samples were grouped into northern and southern Gulf regions that were separated at 28° N latitude. The selection of 28° N latitude was based on the changes in LFDs/ALKs observed in different grids. For the evaluation of randomness of age samples used in Lombardi-Carson et al.'s study, the LFDs estimated from age and length longline fisheries samples collected between 2000 and 2007 were compared. For the estimation of ALKs, length intervals of 5 cm were used (i.e. length = 50 cm means 50 cm ≤ length < 55 cm). All lengths were fork length in centimeters.

Results and Discussion

1. Comparisons of LFDs/ALKs/AFDs among fishing grids

LFD

- a. There were gradual increases in the proportion of larger fish in commercial red grouper samples collected from southern grids (grids 1-5) compared with those collected from northern grids (grids 6 and above) (Figs. 1-3). These changes were more apparent for longline fisheries samples and less apparent for handline and trap fisheries samples (Note: figures only include those LFDs with sample sizes > 100).
- b. There were no obvious differences in LFDs between longline and handline fisheries samples in most grids (Fig 4). This finding may mean that there is no significant difference in gear selectivity between the two gear types. The proportion of larger fish was significantly greater for samples collected from trap fisheries in grid 7 than those collected from longline fisheries (Fig 5).

AFD

- a. There were gradual increases in the proportion of older fish in commercial red grouper samples collected from southern grids (grids 1-5) compared with those

collected from northern grids (grids 6 and above) (Fig 6-7). These changes were more apparent for longline fisheries samples and less apparent for handline fisheries samples.

Note that AFDs estimated in this study were only used to make comparisons between different fishing areas. As indicated below, some age samples may not have been randomly selected and thus may not be representative of the population from which these samples were collected.

ALK

- a. There were gradual increases in the proportion of older fish for given lengths (length 50 and 55) for samples collected from southern grids (grids 1-5) compared with those collected from northern grids (grids 6 and above). These changes in ALKs were more apparent in longline fisheries samples (Fig 10) than in handline fisheries samples (Fig 11).
- b. Direct comparisons of ALKs estimated from longline and handline samples showed that there were significant differences in ALKs between the two types of samples (Fig 12).

2. Comparisons of LFDs between age and length samples for 2000-2005

LFDs of age samples collected from longline fisheries samples between 2000 and 2005 were noticeably different from LFDs of length samples (Fig 8-9). In particular, a much greater portion of larger fish were selected in the south, which may explain the increases in lengths-at-age and changes in growth parameter seen in Lombardi-Carson et al.'s study.

3. Comparisons of LFDs/ALKs between northern and southern Gulf for years 2000-2013

- a. There was a greater proportion of larger fish in commercial longline and handline samples collected from the southern Gulf compared with those collected from northern Gulf for most years examined (Fig 13-16). These differences could be due to changes in either age or size-related movement or selectivity.
- b. There was a greater proportion of older fish for length interval 50 and 55 cm in commercial longline and handline samples collected from the southern Gulf compared with those collected from the northern Gulf for most years examined (Figs. 17-20). These differences may be due to changes in either age-related movement or selectivity.

Conclusions

1. The proportion of larger and older fish progressively increased from north to south. These gradual changes in AFDs/LFDs/ALKs from the northern Gulf toward the southern Gulf do not lend support to the idea that two distinctly different stocks exist in the Gulf of Mexico.
2. The over-sampling of larger age samples in the southern Gulf, particularly from longline fisheries, may explain the differences in growth and lengths-at-age observed in Lombardi et al.'s study. Estimated growth parameters, lengths-at-age and age frequency distributions from these non-random age samples may need to be reweighted by random length samples.
3. The proportions of older fish for a given length (i.e., age-at-length) are consistently greater in the south than in the north for most years examined. This finding suggests that (a) age may be a major driving force for the movement of older and larger fish to the south, or (b) age selectivity may be different in the northern and southern Gulf.
4. Estimated LFDs from samples collected in the southern Gulf have a greater proportion of larger fish than those estimated from samples collected in the northern Gulf for most years observed. These differences could be due to either age or size related movement or selectivity. It is not clear whether and how much size related movement or selectivity contribute to the observed differences in LFDs between the northern and southern Gulf.

References

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Lombardi-Carlson, L., Fitzhugh, G., Palmer, C., Gardner, C., Farsky, R., Ortiz, M. 2008. Regional size, age and growth differences of red grouper (*Epinephelus morio*) along the west coast of Florida. *Fisheries Research* 91:239-251.

Table 1. Sample sizes for length samples collected from commercial longline, handline and trap fisheries from the north (N) and south (S) regions of the Gulf of Mexico between 1984 and 2013.

Year	Handline/N	Handline/S	Longline/N	Longline/S	Trap/N	Trap/S
1984	161	1222	107	1014		18
1985	39	2012	537	1178		900
1986	10	510	242	5519		1244
1987	7	1099	75	2483		766
1988		1137	146	1229		
1989	18	589	176	1617		341
1990	89	856	999	9889		359
1991	169	1681	1351	10942	43	367
1992	447	1998	180	8218	196	647
1993	1129	1387	1453	8232	4	453
1994	1072	2163	1081	7136		207
1995	1873	1425	2511	8586		342
1996	1251	1843	2901	6855	415	287
1997	1377	1040	4743	8925	1159	363
1998	1274	2205	4812	24121	638	422
1999	3263	3489	6988	37245	1503	380
2000	2884	4869	5038	25125	2185	517
2001	3413	3545	3665	16342	3096	866
2002	2706	2758	2695	15425	1689	489
2003	1565	1412	1402	12261	1209	133
2004	1553	1299	1150	9823	20	364
2005	1298	590	1839	5829	377	207
2006	700	173	1441	3049	803	186
2007	1340	94	522	2368		
2008	1178	305	1154	3499		
2009	2642	1390	314	1652		
2010	1195	2138	372	2028		
2011	4759	1375	1387	3283		
2012	7458	3270	2443	4697		
2013	6461	3461	1436	5770		

Table 2. Sample sizes for age samples collected from commercial longline and handline fisheries from the north (N) and south (S) regions of the Gulf of Mexico between 1991 and 2013.

Year	Handline/N	Handline/S	Longline/N	Longline/S
1991	28	15	35	2
1992	20	22	1	140
1993	81	12	10	190
1994	184	55	24	64
1995	178	2	14	126
1996	135	6		96
1997	35			7
1998	17	22	37	85
1999	53	24	96	547
2000	144	62	137	268
2001	365	210	872	338
2002	155	418	607	460
2003	314	247	234	846
2004	528	534	200	953
2005	398	228	269	1186
2006	299	330	163	375
2007	436	61	147	452
2008	377	126	143	366
2009	801	570	185	1848
2010	482	548	103	547
2011	439	190	101	398
2012	585	434	192	669
2013	392	166	275	855

Fig 1. Length frequency distributions (LFD) for red grouper length samples collected from longline fisheries at different grids in the Gulf of Mexico between 2000 and 2013.

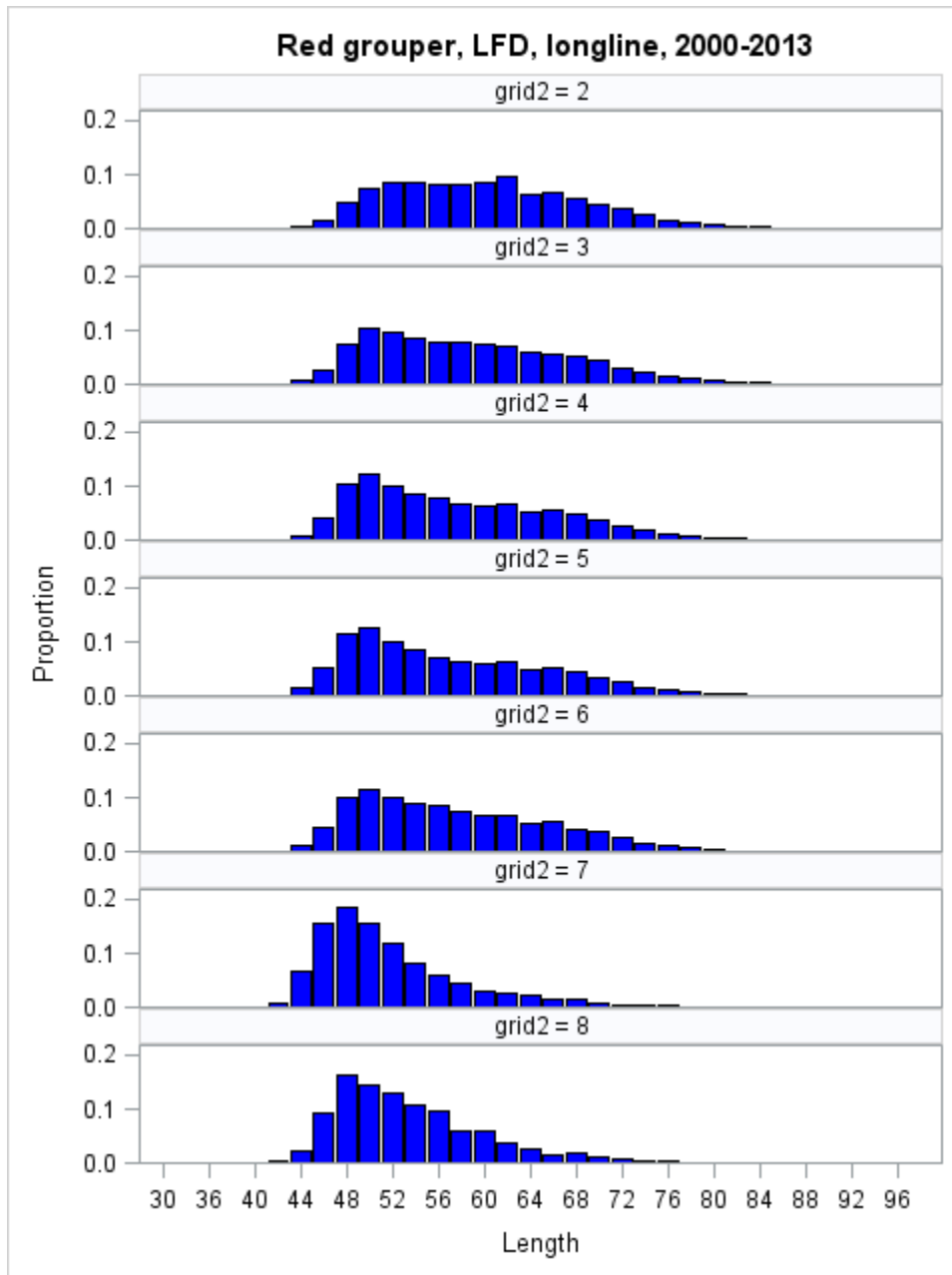


Fig 2. Length frequency distributions (LFD) for red grouper length samples collected from handline fisheries at different grids in the Gulf of Mexico between 2000 and 2013.

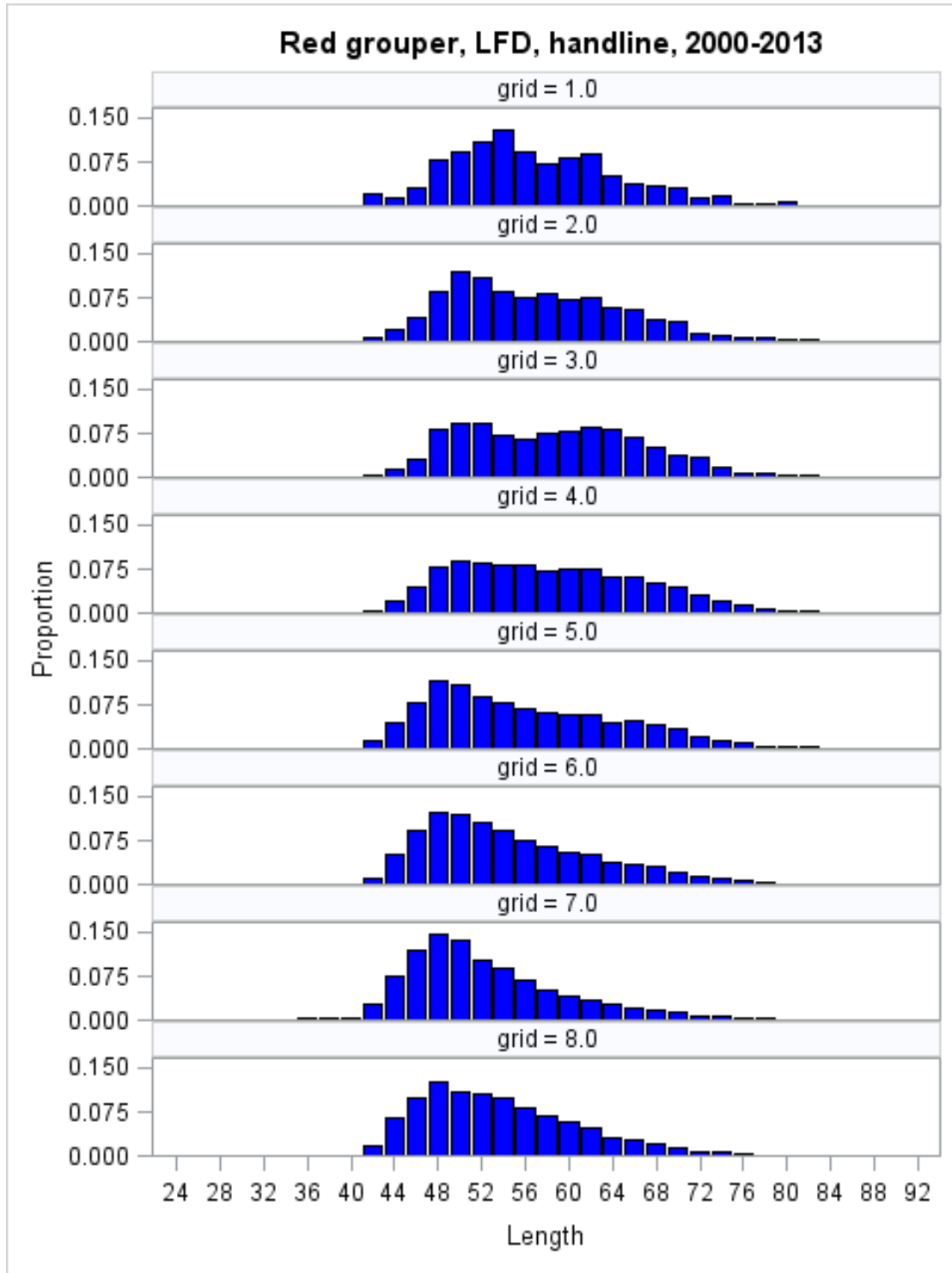


Fig 3. Length frequency distributions (LFD) for red grouper length samples collected from trap fisheries at different grids in the Gulf of Mexico between 2000 and 2013.

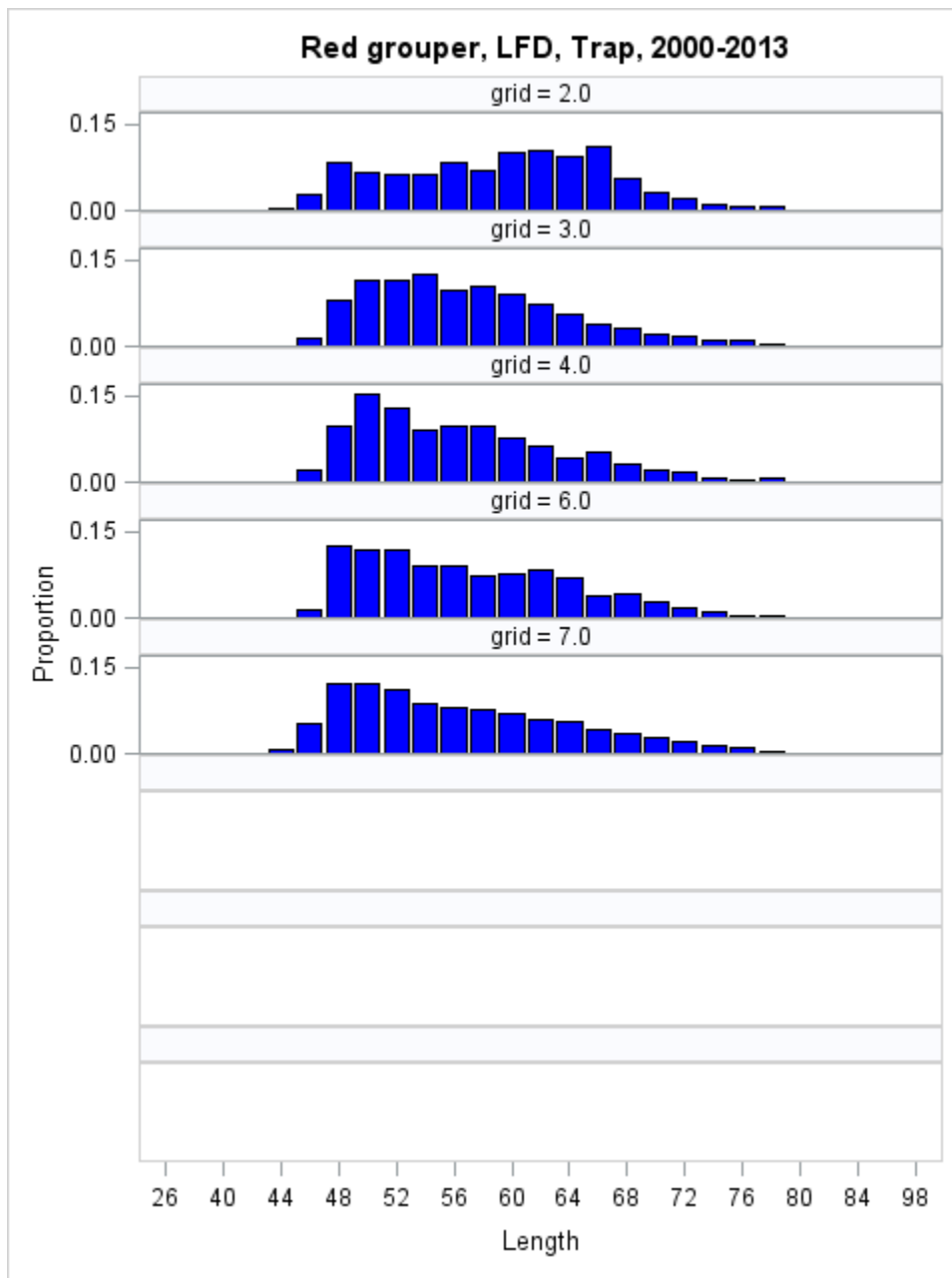


Fig 4. Comparisons of length frequency distributions (LFDs) between longline and handline fisheries at different grids in the Gulf of Mexico between 2000 and 2013.

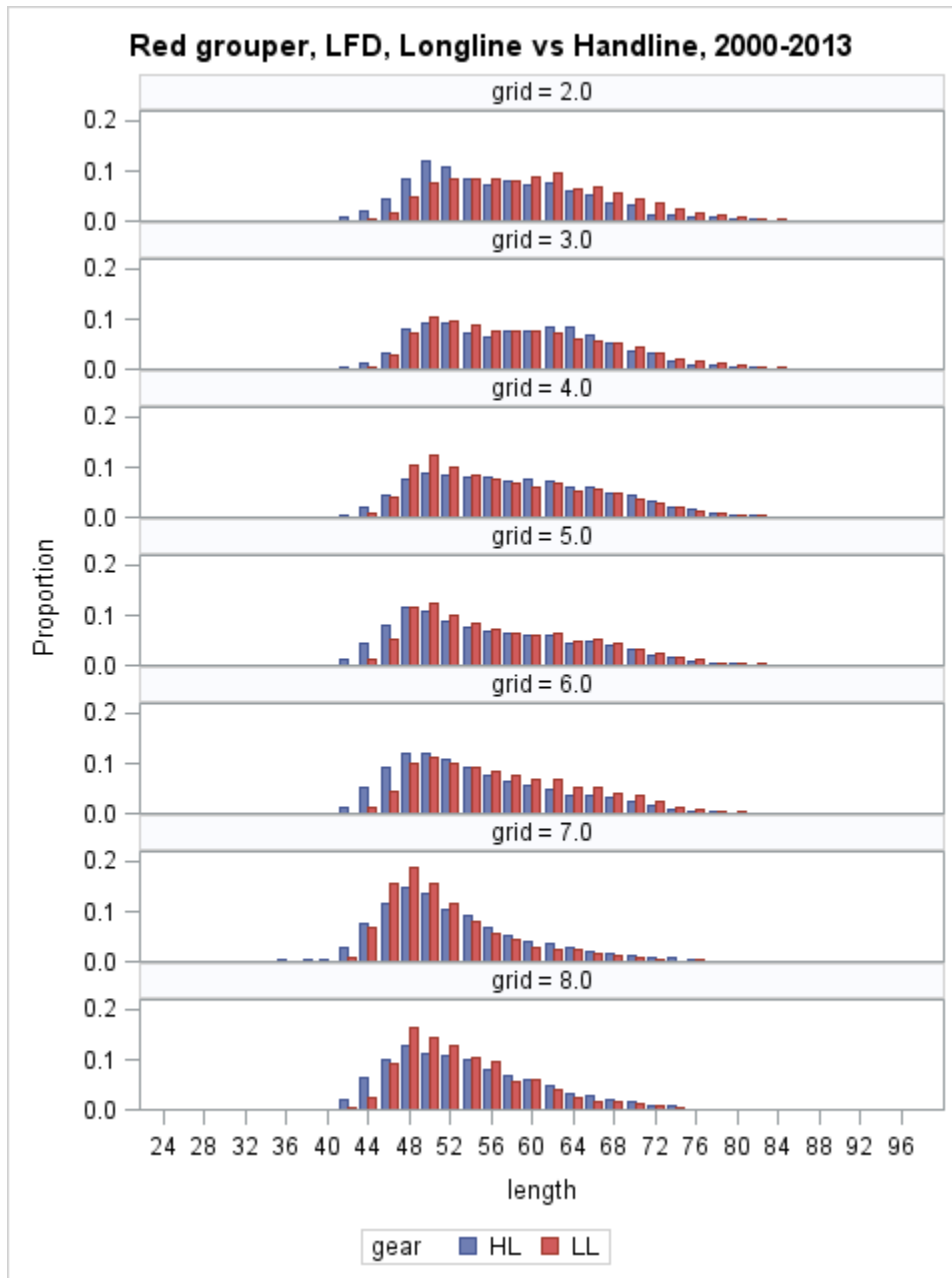


Fig 5. Comparisons of length frequency distributions (LFDs) between longline and handline fisheries at different grids in the Gulf of Mexico between 2000 and 2013.

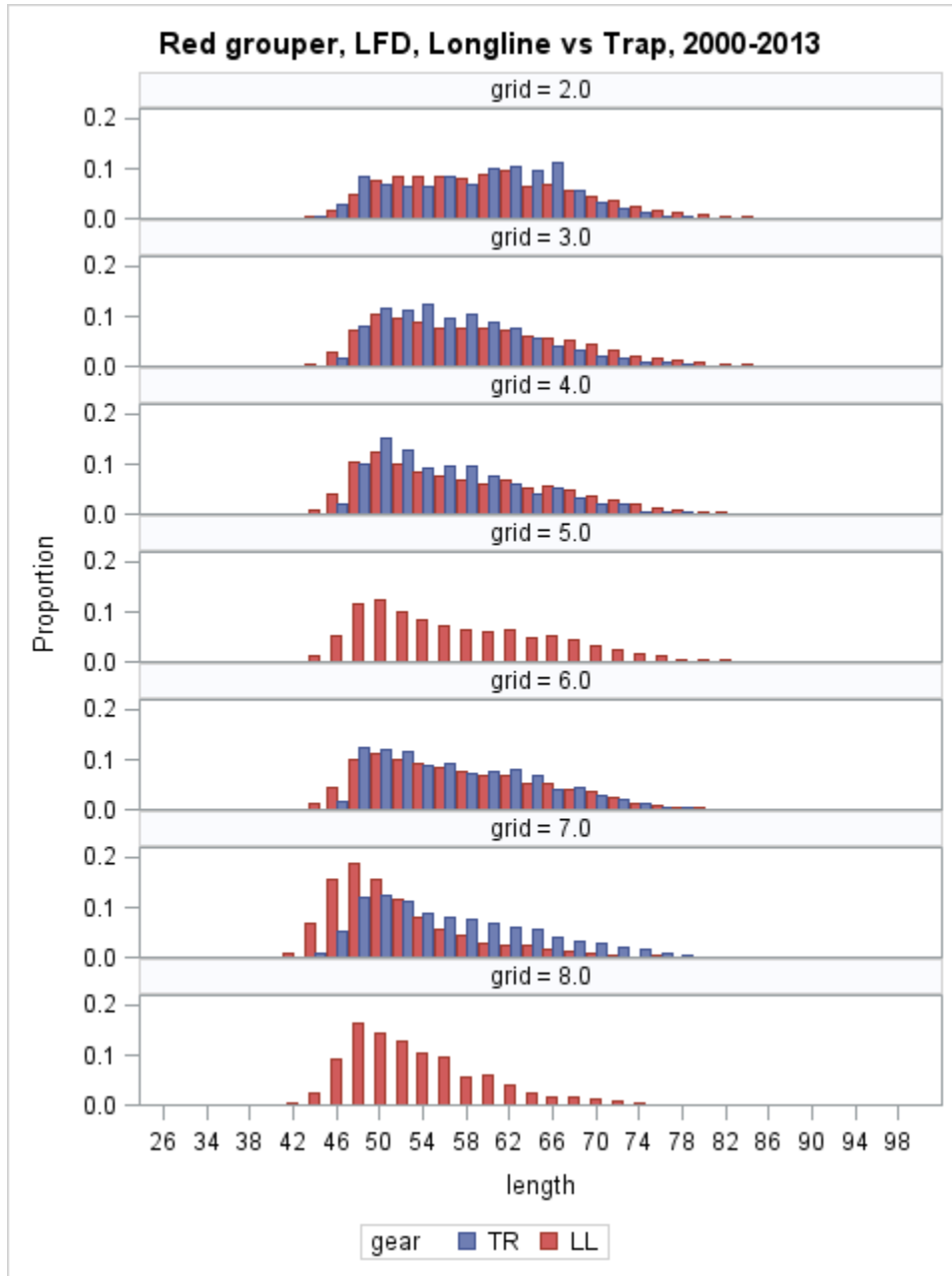


Fig 7. Age frequency distributions (AFDs) for red grouper length samples collected from longline fisheries at different grids in the Gulf of Mexico between 2000 and 2013.

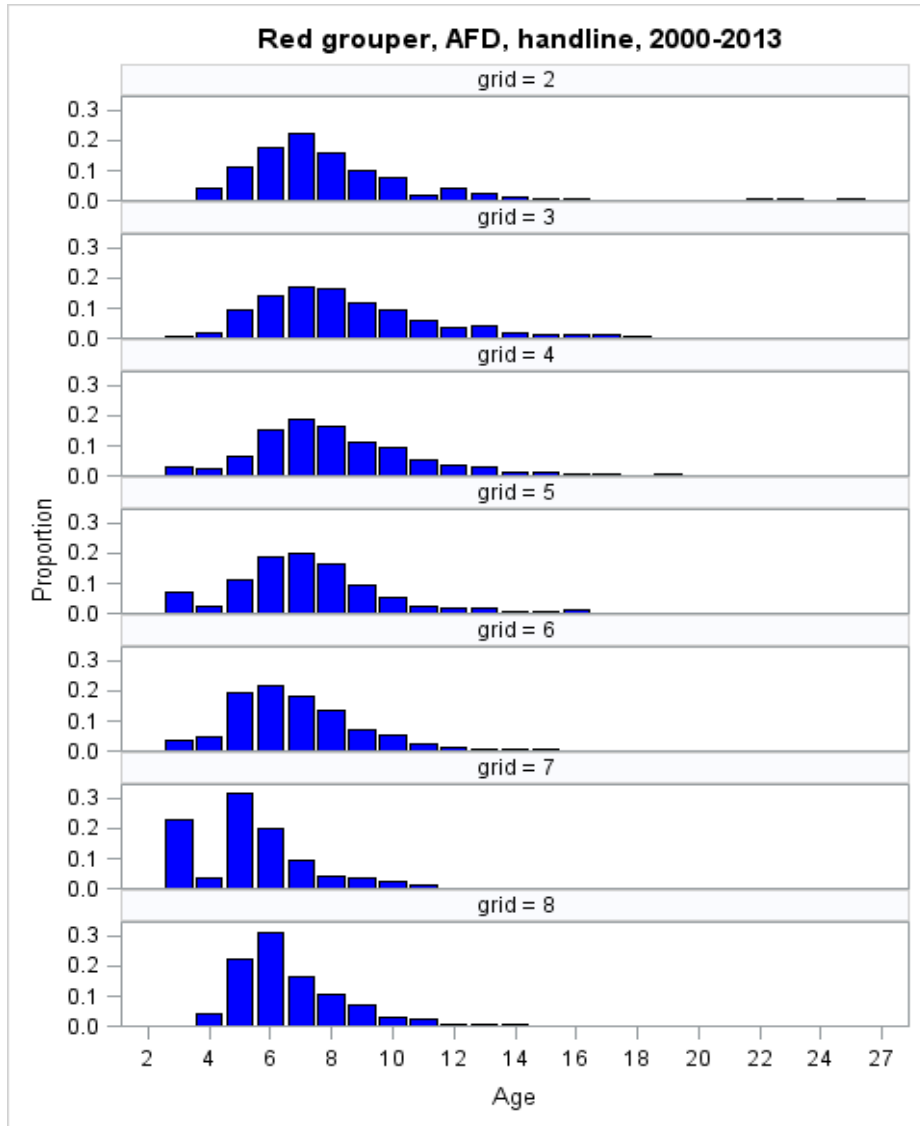


Fig 8. Comparisons of length frequency distributions (LFDs) between age and length red grouper samples collected from commercial longline fisheries from 2000 to 2003.

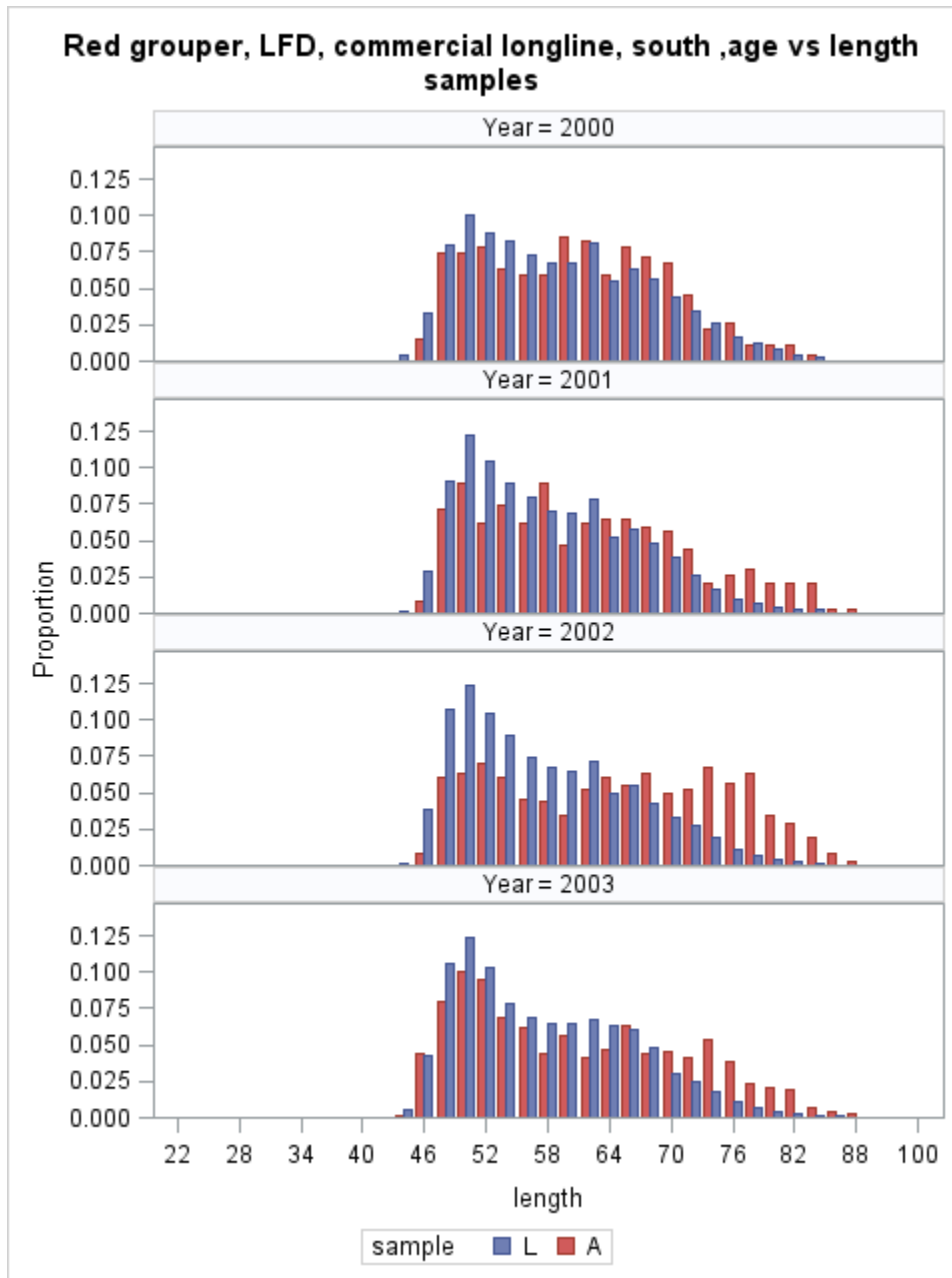


Fig 9. Comparisons of length frequency distributions (LFDs) between age and length red grouper samples collected from commercial longline fisheries from 2004 to 2007.

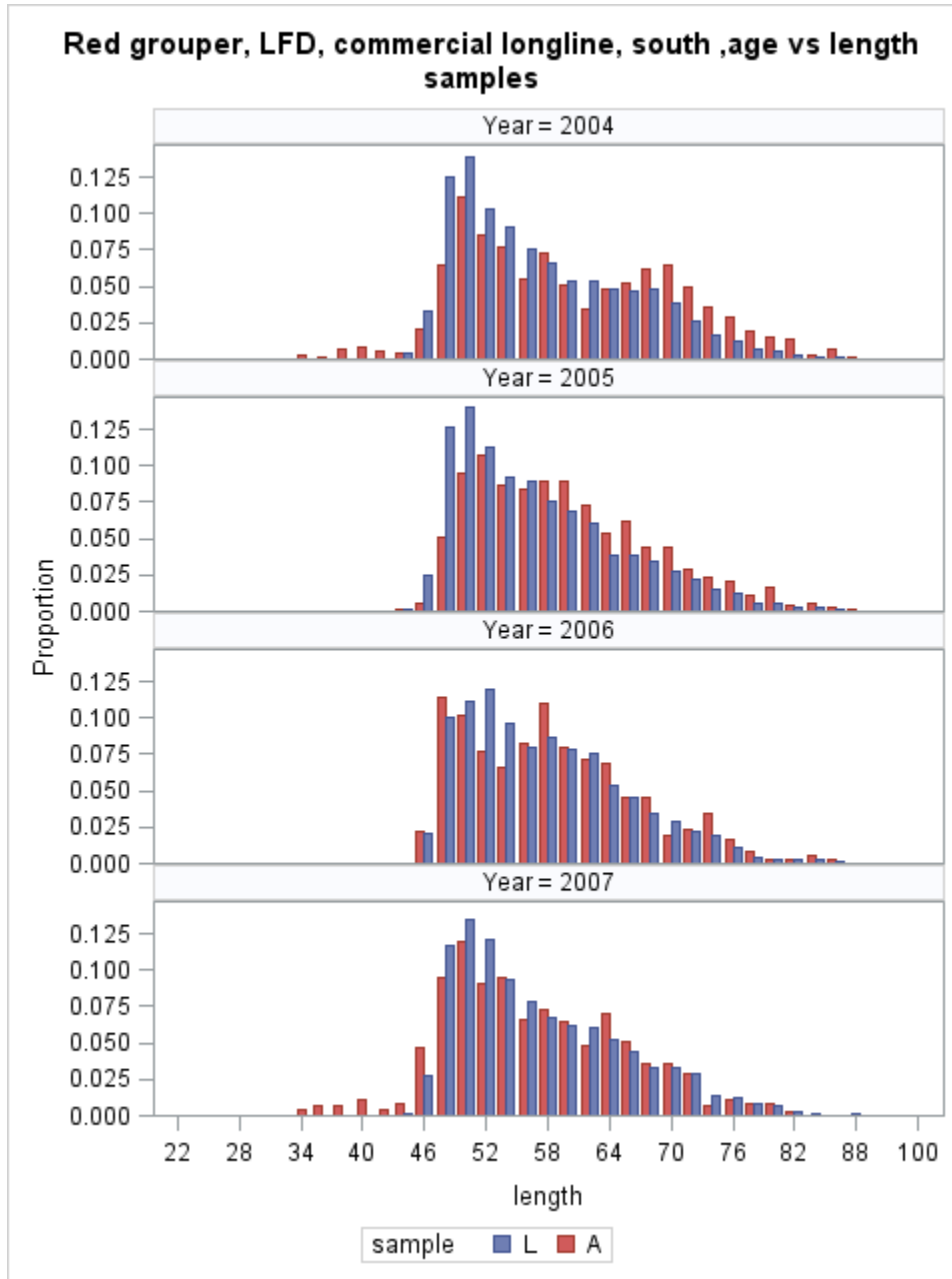
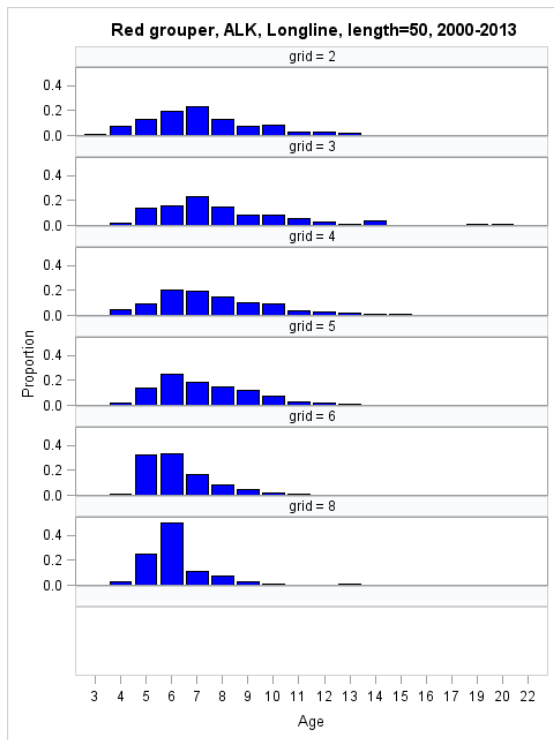


Fig 10. Age length keys (ALKs) for length intervals 50 and 55 cm for red grouper length samples collected from longline fisheries at different grids in the Gulf of Mexico between 2000 and 2013. (Note: length 50 cm means 50 cm \leq length < 55 cm)

(a) Length 50 cm



(b) length 55 cm

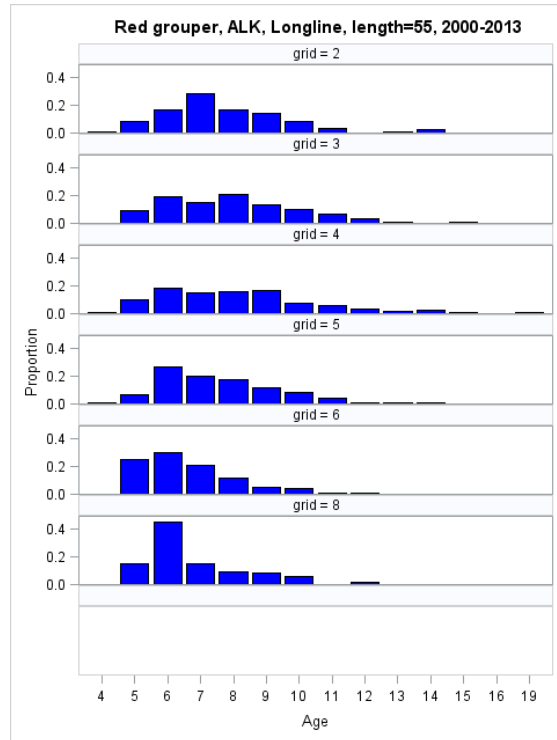


Fig 11. Age length keys (ALKs) for length intervals 50 and 55 cm for red grouper length samples collected from handline fisheries at different grids in the Gulf of Mexico between 2000 and 2013. (Note: length 50 cm means 50 cm \leq length < 55 cm)

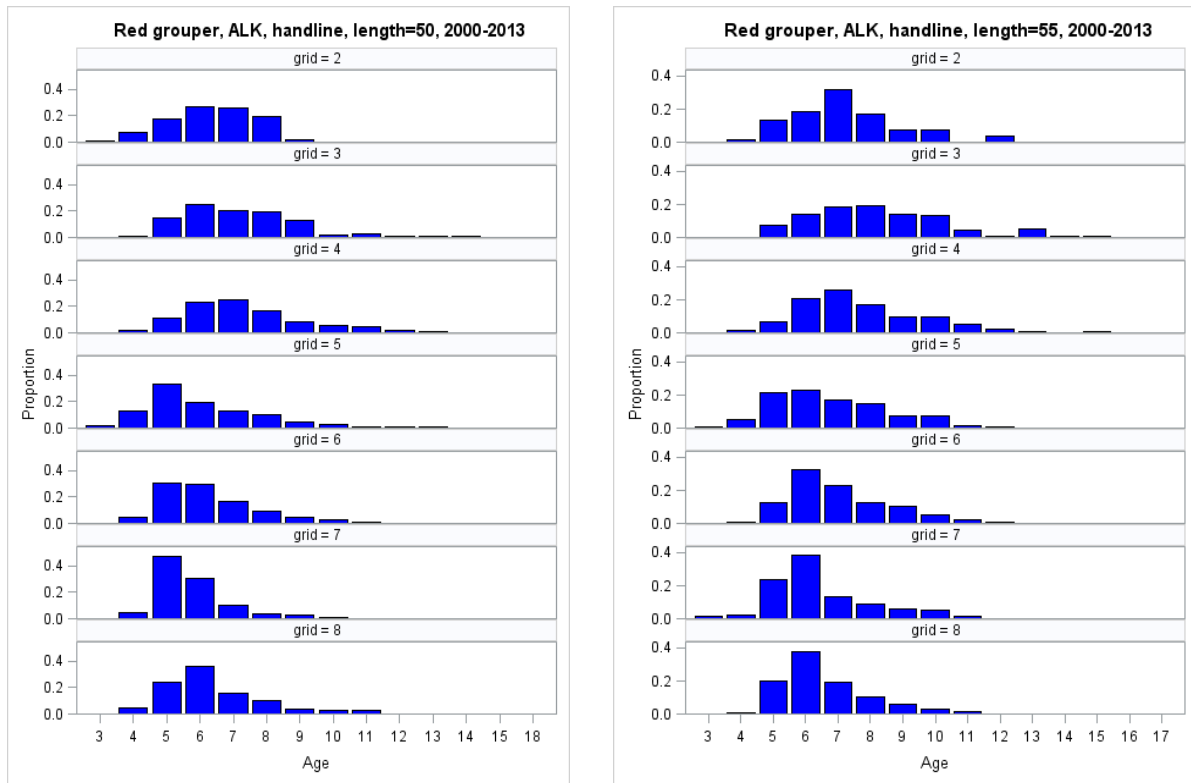


Fig 12. Comparisons of age length keys (ALKs) for length interval 50 cm between longline and handline fisheries at different grids in the Gulf of Mexico between 2000 and 2013.

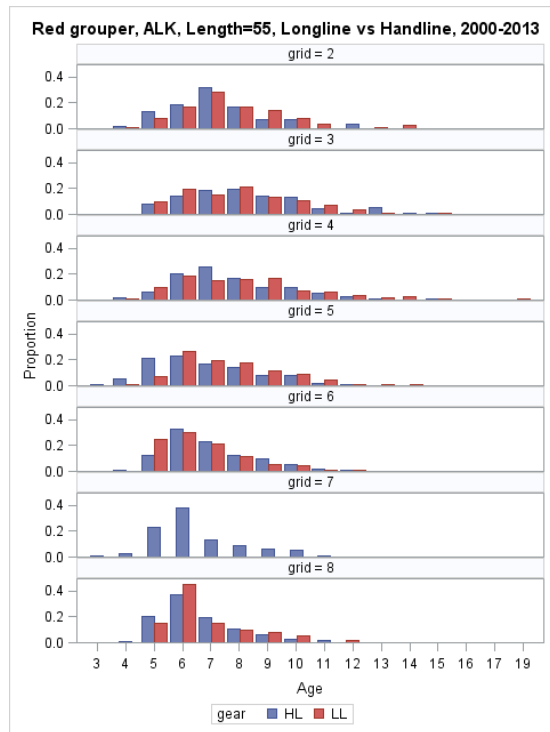
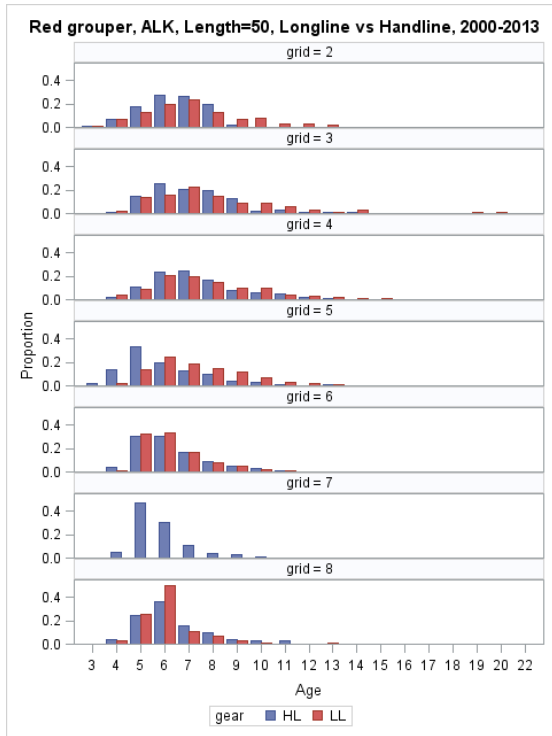


Fig 13. Comparisons of length frequency distributions (LFDs) between longline samples collected from the northern (N) and southern (S) Gulf between 2000 and 2006.

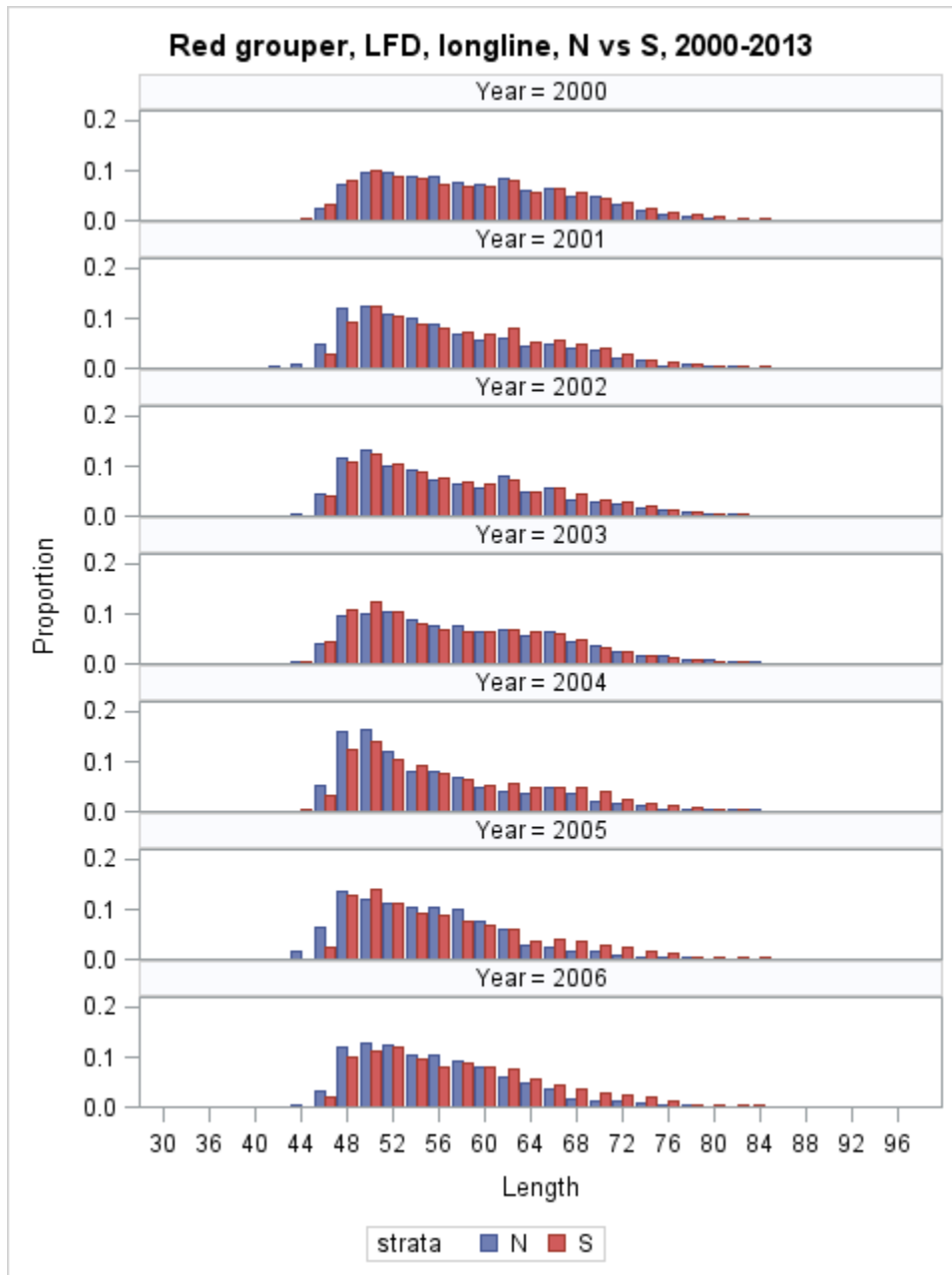


Fig 14. Comparisons of length frequency distributions (LFDs) between longline samples collected from the northern (N) and southern (S) Gulf between 2007 and 2013.

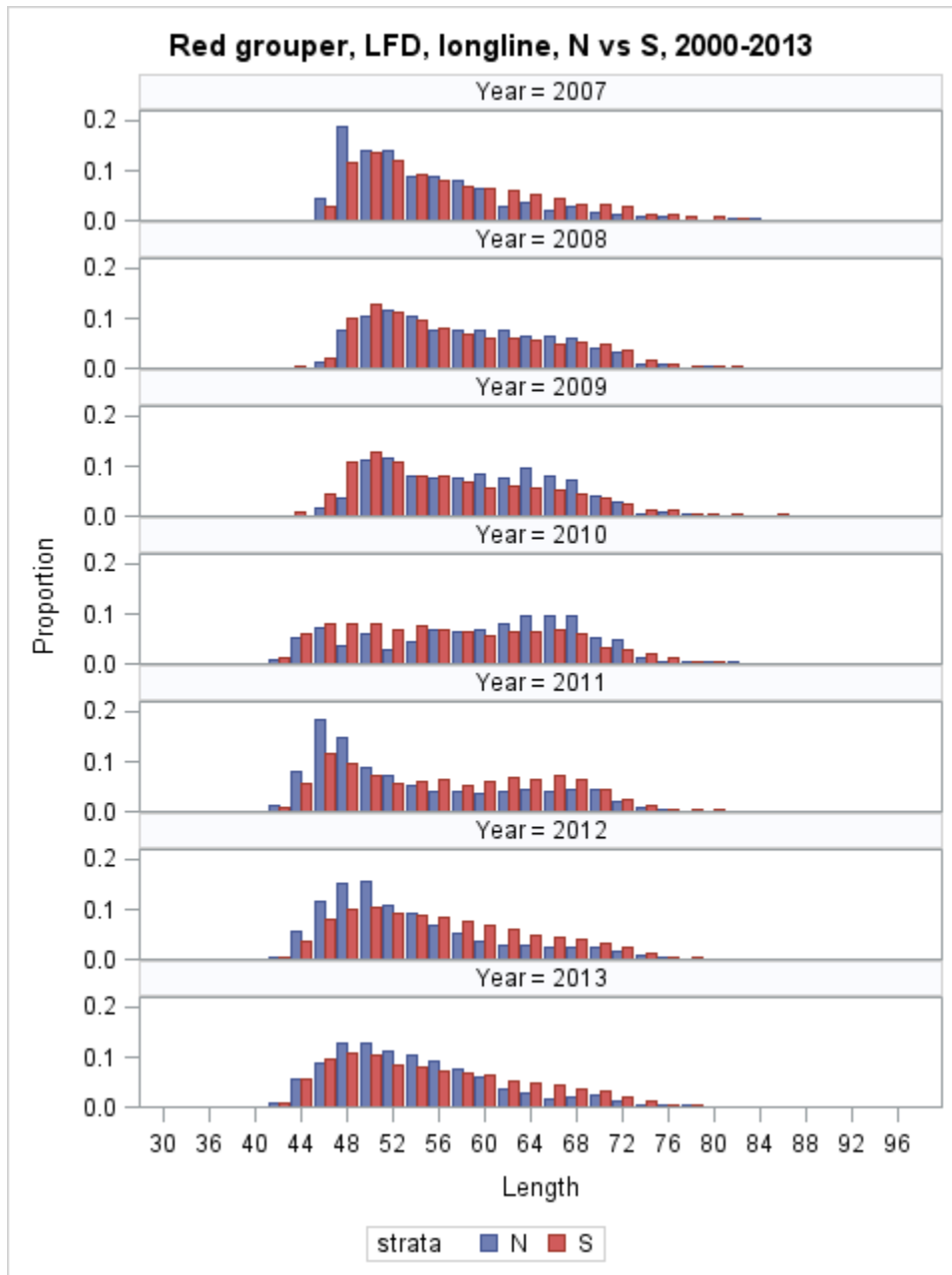


Fig 15. Comparisons of length frequency distributions (LFDs) between handline samples collected from the northern (N) and southern (S) Gulf between 2000 and 2006.

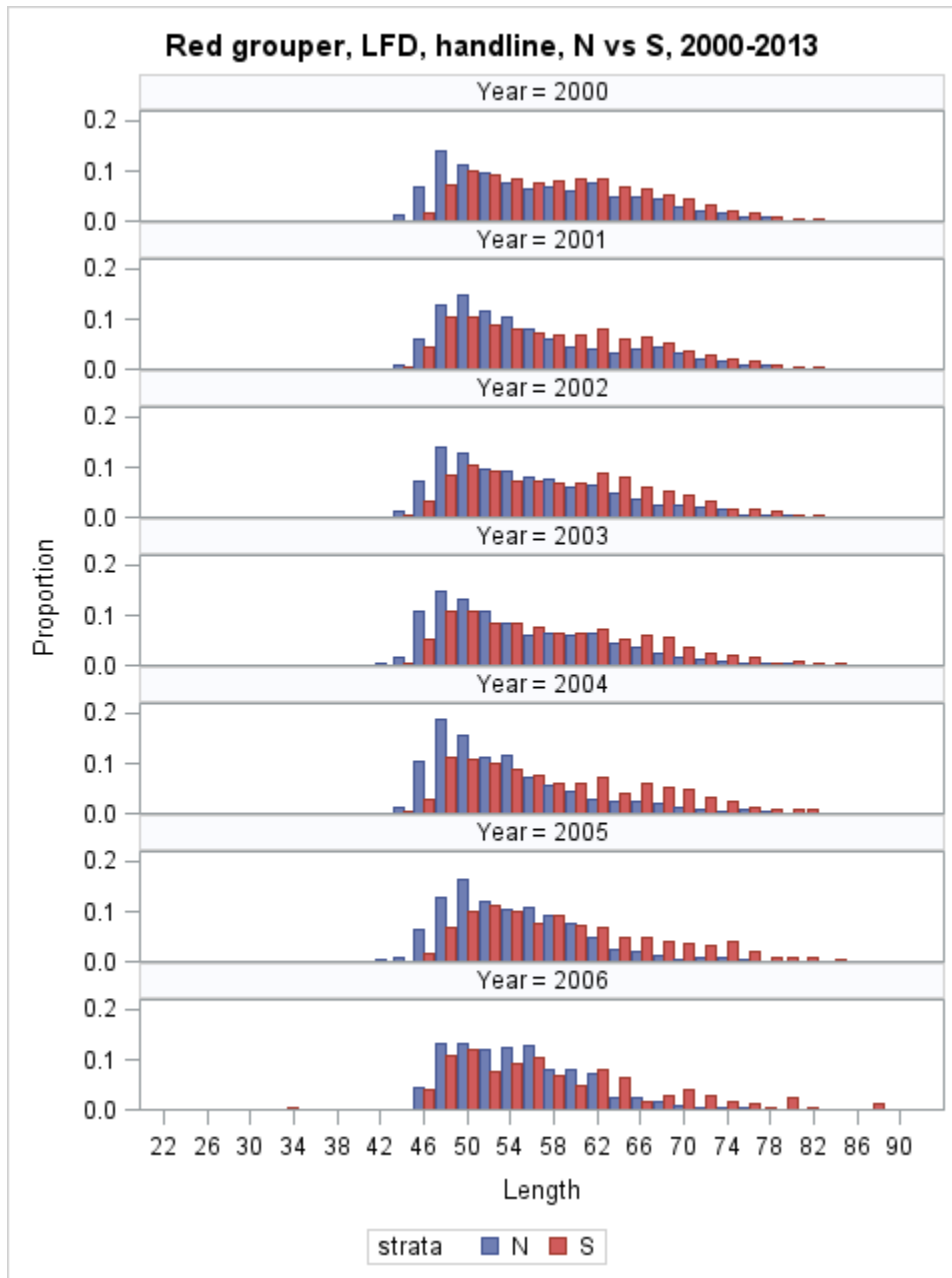


Fig 16. Comparisons of length frequency distributions (LFDs) between handline samples collected from the northern (N) and southern (S) Gulf between 2007 and 2013.

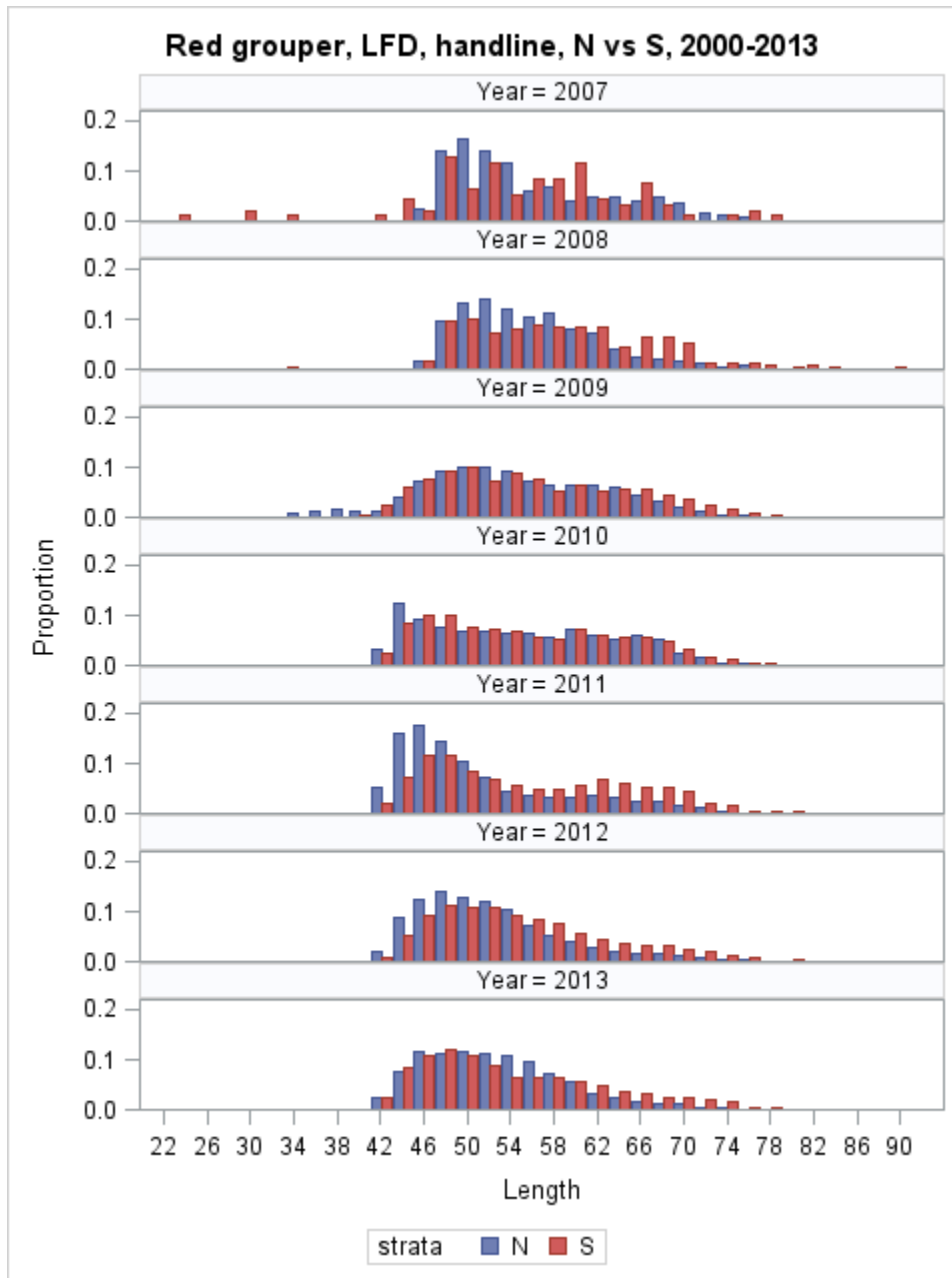


Fig 17. Comparisons of age length keys (ALKs) for length 50 cm between commercial samples collected from the northern (N) and southern (S) Gulf between 2000 and 2013.

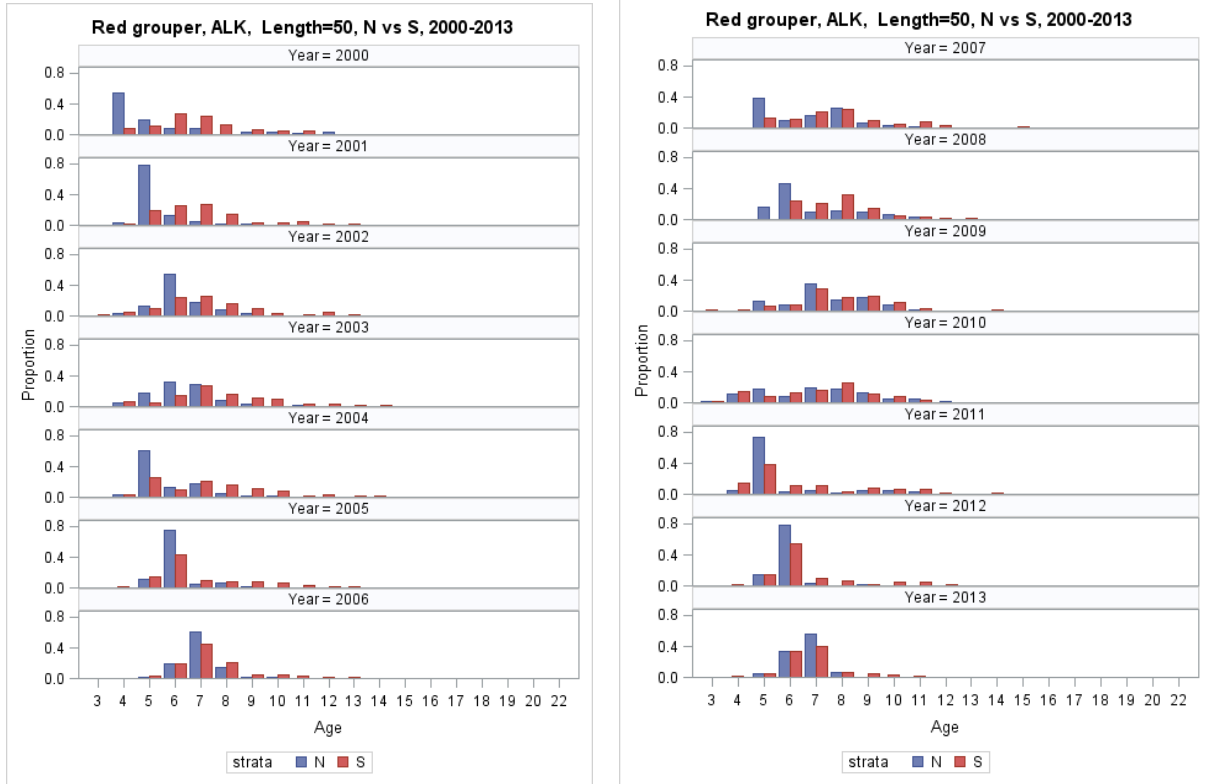


Fig 18. Comparisons of age length keys (ALKs) for length 55 cm between commercial samples collected from the northern (N) and southern (S) Gulf between 2000 and 2013.

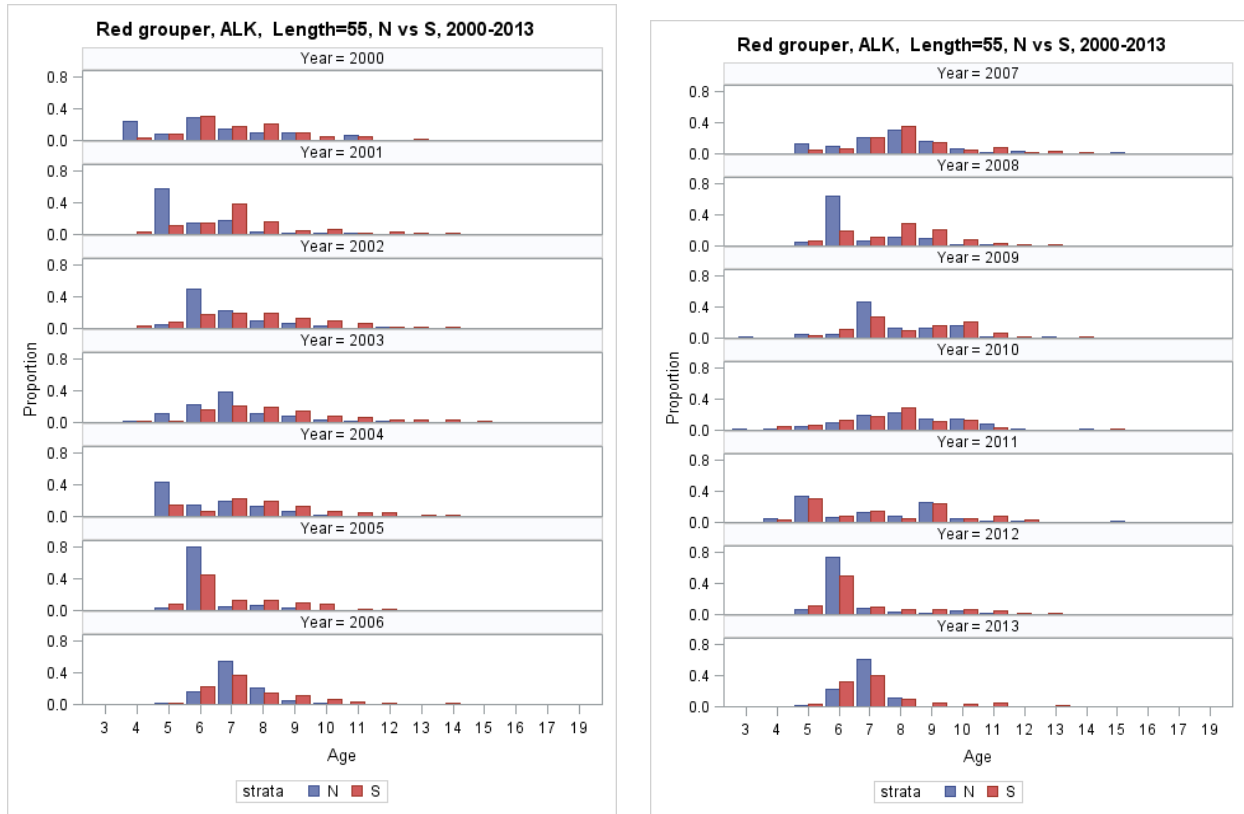


Fig 19. Comparisons of age length keys (ALKs) for length 50 cm between commercial longline samples collected from the northern (N) and southern (S) Gulf between 2000 and 2013.

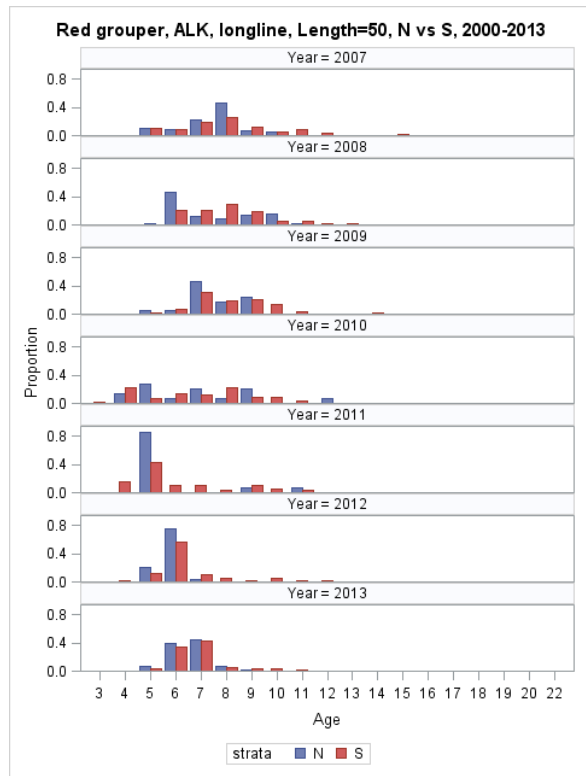
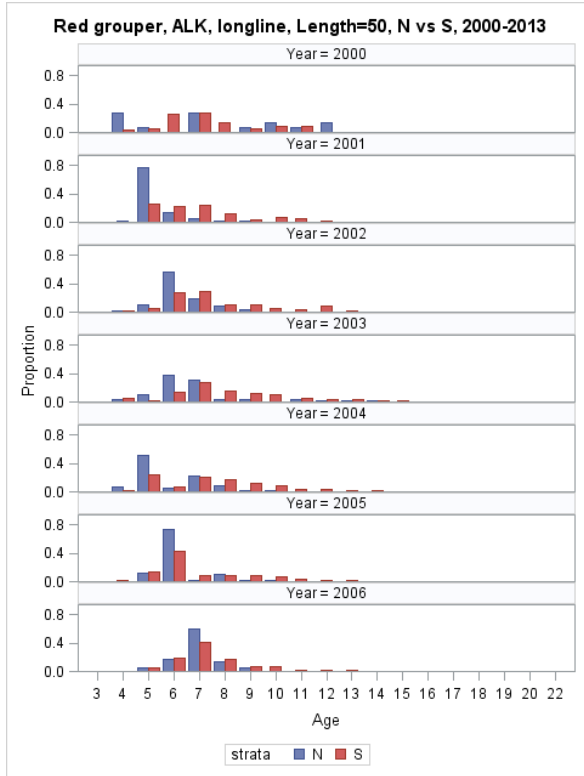


Fig 20. Comparisons of age length keys (ALKs) for length 50 cm between commercial handline samples collected from the northern (N) and southern (S) Gulf between 2000 and 2013.

