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Selected sampling issues regarding the length/age frequency distributions of red groupers caught by commercial fisheries in the Gulf of Mexico from 1984 to 2005

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INTRODUCTION

This paper discusses a few sampling issues that may influence length/age frequency distributions for commercial red grouper samples collected by TIP (Trip interview program) samplers from red grouper landings in the Gulf of Mexico. Trips and length information were from the TIP database housed in the Southeast Fisheries Center, while age data were from the age database housed in the Panama City Laboratory. The aims of this paper are to identify sampling irregularities which may contribute to variations in length/age frequency distributions, and to recommend remedies to minimize the impact of these sampling irregularities on length/age frequency distributions.

I. SAMPLE SIZE

Inadequate sample sizes for individual sampling trips can have a significant impact on the length frequency distributions (LFDs) of fish samples (Ref. 1 and 2). In general, LFDs constructed by adding together sampling trips with small sample sizes tend to be flatter and have higher percentages of larger fish. Sample sizes for individual red grouper TIP sampling trips have varied over time during the past twenty two years:

(1) 1984-1989: The regulation setting 20 inches as the lower size limit for red groupers went into effect in 1990. The range of sizes (11-37 inches) for fish caught before 1990 was much larger than the range of sizes (18-36 inches) for fish caught after 1990 (Fig 1). Differences in sample sizes have a greater impact on the LFD as the variability in lengths increases. Fig 2 shows combined LFDs for different sizes of red grouper commercial TIP samples collected from1984 to 1989. There is a clear difference between LFDs with sample sizes larger than 30 and those with sample sizes smaller than 30. The percents of trips with different sample sizes are shown in Tables 1 to 3. Although small sample sizes may contribute to the irregularities seen in LFDs, it is difficult to explain the large variations in yearly LFDs for red groupers from 1984 to1989 (Ref. 3). One factor that may have contributed to these LFD variations is the large variation in the number of trap samples collected during this period (also see discussion in Ref. 3). Another factor may have been the high percentage of sorted samples (Table 4). Such samples can require additional effort on the part of the sampler to ensure that they are random.

(2) 1990-2005: Fig 3 shows combined LFDs for different sizes of red grouper commercial TIP samples collected from 1990 to 2005. Sample size had no apparent effect on combined LFDs. This may be due to smaller ranges in lengths and to overall larger numbers of samples. However, LFDs for combined trips with small sample sizes are different from LFDs for all trips when LFDs are examined on a yearly basis (Figs 15 and16; also see below). Also, after random age sampling started, the percent of trips with small sample sizes increased (Table 1,8, and 9).

II. WEIGHTING OF INDIVIDUAL TRIPS

Since LFDs vary greatly among individual trips, it is necessary to weight individual trips by landing weight when constructing the LFDs for combined individual trips (Ref. 2). Most of the red grouper TIP sampling trips had records of sampling weights (Table 5). Fig 4 shows the relationship between landing weights for individual trips and sample sizes for individual trips in selected years. It is apparent that in most cases the sample sizes for individual trips did not coincide with the landing weights for individual trips. Thus, it is recommended that LFDs for trips samples be weighted with the landing weights for individual trips.

III. OTOLITH SAMPLES

TIP samplers have consistently collected red grouper otolith samples from commercial catches since 1991 (Tables 6 and 7; data based on TIP records). From 1991 to 2000, the number of otoliths collected per year was relatively small, representing less than 4% of total TIP samples collected (Table 6). Also, some otolith samples obtained during that period may have been collected for the purpose of building age-length keys or for other biological studies. The percentage of otoliths collected has increased sharply since 2001. However, due to limitations in the capacity to process otoliths, red grouper otolith samples collected from longline fisheries were subsampled (Table 10), which limits the percentage of aged otolith samples (data from the Panama City age database) to 9-16% of the original length samples (Table 6).

(A) Comparison of LFDs between TIP length samples and otolith samples

(1) 1991-2000: The LFDs for TIP lengths and otolith samples were noticeably different during this period (Fig 5). These differences are particularly pronounced in 1991, 1992, 1996, and 1997. In general, the percent of large fish in otolith samples compared to length samples increased. Differences in LFDs between length and otolith samples are also seen in different gear types (Figs 6-8). Two factors may have contributed to the differences in LFDs between length and otolith samples in those years. First, in the earlier years, some otolith samples may have been collected with the age-length-key method (Ref. 1). Second, extracting otoliths from fish usually requires more time, which frequently limits the sample size for individual trips. Small sample sizes may also lead to irregular LFDs (Ref. 1 and 2; also see below). Thus, it may be more appropriate to use the age length key method to derive age frequency distributions (AFDs) from LFDs instead of using AFDs obtained directly from otolith samples collected from1991 to 2000.

(2) 2001-2005: In general, LFDs between length and otolith samples collected from 2001 to 2005 were similar (Fig 5). However, differences in LFDs between length and otolith samples can be observed in different gear types (Figs

9-13). Comparison of LFDs between TIP length samples and otolith samples subsampled for age determinations and collected from longline fisheries are shown in Fig 14. The high percentage of trips with small otolith sample sizes during these years (Tables 8 and 9; also see below) remains a problem for using AFDs obtained directly from otolith samples.

(B) Otolith sample sizes

One potential problem of random age sampling is the limitation in sample sizes due to insufficient sampling time during dock-site sampling. This problem is evident in the large percentage of trips with small sample sizes when otoliths were collected (Tables 8 and 9). From 1991 to 2000, small sample sizes may have contributed to differences in LFDs between otolith and length samples. After 2001, relatively large quantities of otoliths were collected, and the influence of small-sized otolith samples on overall LFDs was less evident. However, the differences in LFDs between trips with small sample sizes and the original LFDs of TIP length samples from 2002 to 2005 were still quite large (Figs 15 and 16). It may be best to eliminate these records when constructing AFDs for these years.

(C) Age length keys

Because there are essentially no otolith TIP samples collected for commercial fisheries before 1991, AFDs for these years need to be established by using age length keys. The fact that LFDs differ considerably between TIP length samples and otolith samples taken from 1991 to 2000 also suggests that AFDs for these years should be constructed from age length keys. Although yearly LFDs between TIP length samples and otolith samples were similar from 2001 to 2005, the small number of otoliths from trap fisheries may still require the use of age-length keys to develop AFDs for these years.

Age length keys can vary considerably from year to year for various reasons. Fig 17 shows AFDs for samples with lengths between 19.5 to 20.5 inches (length interval 20 inches). Part of this variation between various years may be due to small sample sizes (Table 11). Fig 18 illustrates how small sample sizes can influence the AFD. When all samples (1991-2005) with length intervals of 20 inches were resampled with a sample size of 50, the resulting AFDs often varied considerably with each resampling. Small sample sizes are particularly a problem for length intervals larger than 30 inches.

Another factor that may contribute to the variation of age length keys relates to how age is determined from otoliths. For fish caught between January 1 and June 30, annulus counts might have increased by one depending on the marginal edge completion, the determination of which is subjectively determined by otolith readers. For fish caught after June 30, fish were assigned an age equal

to the annulus count (Ref. 4). Thus, the proportion of samples collected at different seasons may also influence the outcome of AFDs. Fig 19 shows the AFDs for otolith samples taken from fish with lengths between 20 to 22 inches. These samples were collected from 2001 to 2005. The AFDs for otolith samples collected after July 1 consistently have smaller proportions of older fish than AFDs for otolith samples collected before July 1. Although these differences are not very significant in some years, AFDs can be significantly influenced if the number of otolith samples collected before July 1 differs greatly from the number of otolith samples collected after July 1.

CONCLUSIONS

1. LFDs for TIP length samples and otolith samples collected from 1991 to 2000 are inconsistent. It is recommended that the age length key method be used to develop AFDs for data collected from 1984 to 2000.

2. LFDs differ less between TIP length samples and otolith samples collected from 2001 to 2005. However, trips with small otolith sample sizes had LFDs that differed from the overall LFD. It may be best to eliminate those trips with very small sample sizes when AFDs are determined. Also, otolith sample numbers for trap fisheries are very small, so samples from this fishery type may still require the use of age length key methods to develop AFDs.

3. The yearly age-length relationships can vary significantly with changes in sample sizes and sampling seasons.

4. The sample sizes of individual trips did not coincide with the landing weights of individual trips. It is recommended that length samples be weighted by the landing weights of individual trips.

5. Large variations in yearly length frequency distributions from1984 to 1989 may be due partly to (1) small sample sizes, (2) sorted samples, and (3) variations in trap samples.

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Table 1. Percent of trips and of red grouper samples that had sample sizes less than 5 from 1984 to 2004 (ss- sample size of individual trip).

Year	Number of trip	Number of trip with ss <=5	Percent	Number of TIP samples	Number of samples with	Percent
1984	68	5	7.35%	2711	13	0.48%
1985	95	8	8.42%	5310	21	0.40%
1986	154	19	12.34%	7532	49	0.65%
1987	103	15	14.56%	4639	48	1.03%
1988	47	5	10.64%	2560	15	0.59%
1989	50	14	28.00%	2810	30	1.07%
1990	150	29	19.33%	12204	60	0.49%
1991	200	49	24.50%	14864	123	0.83%
1992	190	27	14.21%	11692	65	0.56%
1993	264	52	19.70%	12692	114	0.90%
1994	279	52	18.64%	11682	143	1.22%
1995	288	53	18.40%	14737	122	0.83%
1996	292	58	19.86%	13508	147	1.09%
1997	318	48	15.09%	17642	97	0.55%
1998	507	72	14.20%	33508	163	0.49%
1999	561	60	10.70%	52918	146	0.28%
2000	504	53	10.52%	40789	154	0.38%
2001	513	77	15.01%	30933	193	0.62%
2002	521	89	17.08%	25803	226	0.88%
2003	575	146	25.39%	18056	384	2.13%
2004	497	172	34.61%	14297	435	3.04%
2005	450	158	35.11%	10140	347	3.42%

Table 2. Percent of trips and of red grouper samples that had sample sizes larger than 30 from 1984 to 2004 (ss - sample size of individual trip).

Year	Number of trip	Number of trip with ss	Percent	Number of TIP	Number of samples with	Percent
1984	68	36	52.94%	2711	2232	82.33%
1985	95	42	44.21%	5310	4510	84.93%
1986	154	85	55.19%	7532	6674	88.61%
1987	103	54	52.43%	4639	4041	87.11%
1988	47	24	51.06%	2560	2260	88.28%
1989	50	30	60.00%	2810	2722	96.87%
1990	150	76	50.67%	12204	11289	92.50%
1991	200	95	47.50%	14864	13863	93.27%
1992	190	107	56.32%	11692	10662	91.19%
1993	264	124	46.97%	12692	11188	88.15%
1994	279	118	42.29%	11682	9792	83.82%
1995	288	154	53.47%	14737	13279	90.11%
1996	292	140	47.95%	13508	11807	87.41%
1997	318	174	54.72%	17642	15978	90.57%
1998	507	286	56.41%	33508	30932	92.31%
1999	561	399	71.12%	52918	51124	96.61%
2000	504	310	61.51%	40789	38140	93.51%
2001	513	272	53.02%	30933	27871	90.10%
2002	521	226	43.38%	25803	22281	86.35%
2003	575	169	29.39%	18056	13495	74.74%
2004	497	114	22.94%	14297	10873	76.05%
2005	450	112	24.89%	10140	7174	70.75%

Table 3. Percent of trips and of red grouper samples that had sample sizes larger than 50 from 1984 to 2004 (ss- sample size of individual trip).

Year	Number of trip	Number of trip with ss >=50	Percent	Number of TIP samples	Number of samples with	Percent
1984	68	13	19.12%	2711	1324	48.84%
1985	95	27	28.42%	5310	3943	74.26%
1986	154	66	42.86%	7532	5956	79.08%
1987	103	29	28.16%	4639	3095	66.72%
1988	47	20	42.55%	2560	2108	82.34%
1989	50	26	52.00%	2810	2551	90.78%
1990	150	57	38.00%	12204	10544	86.40%
1991	200	72	36.00%	14864	13003	87.48%
1992	190	80	42.11%	11692	9576	81.90%
1993	264	91	34.47%	12692	9923	78.18%
1994	279	83	29.75%	11682	8420	72.08%
1995	288	115	39.93%	14737	11812	80.15%
1996	292	90	30.82%	13508	9910	73.36%
1997	318	130	40.88%	17642	14232	80.67%
1998	507	223	43.98%	33508	28488	85.02%
1999	561	333	59.36%	52918	48498	91.65%
2000	504	250	49.60%	40789	35787	87.74%
2001	513	197	38.40%	30933	24980	80.76%
2002	521	154	29.56%	25803	19515	75.63%
2003	575	99	17.22%	18056	10755	59.56%
2004	497	75	15.09%	14297	9449	66.09%
2005	450	53	11.78%	10140	5198	51.26%

Table 4. Percent of red grouper TIP samples that were already sorted at the time of sampling from 1984 to 2004

Year	total number of samples	Sorted samples	Unsorted samples	Percent sorted samples
1984	2711	484	2227	17.85%
1985	5310	4241	1069	79.87%
1986	7532	7028	504	93.31%
1987	4639	4163	469	89.74%
1988	2560	2483	77	96.99%
1989	2810	1364	1446	48.54%
1990	12204	1283	10921	10.51%
1991	14864	116	14559	0.78%
1992	11692	131	11532	1.12%
1993	12692	43	12607	0.34%
1994	11682	103	11466	0.88%
1995	14737	0	14737	0.00%
1996	13508	53	13407	0.39%
1997	17642	159	17483	0.90%
1998	33508	204	33089	0.61%
1999	52918	190	52728	0.36%
2000	40789	318	40471	0.78%
2001	30933	225	30708	0.73%
2002	25803	383	25420	1.48%
2003	18056	1	18055	0.01%
2004	14297	291	13765	2.04%
2005	10140	588	8814	5.80%

Table 5. Percent of red grouper TIP sampling trips that have landing weight information recorded from 1984-2005.

Year	Number of trips	trips with landing weight information	Percent trips with landing weight information
1984	68	58	85.29%
1985	95	68	71.58%
1986	154	124	80.52%
1987	103	97	94.17%
1988	47	43	91.49%
1989	50	39	78.00%
1990	150	137	91.33%
1991	200	152	76.00%
1992	190	168	88.42%
1993	264	223	84.47%
1994	279	232	83.15%
1995	288	242	84.03%
1996	292	266	91.10%
1997	318	274	86.16%
1998	507	469	92.50%
1999	561	528	94.12%
2000	504	472	93.65%
2001	513	474	92.40%
2002	521	439	84.26%
2003	575	454	78.96%
2004	497	462	92.96%
2005	450	436	96.89%

Table 6. Numbers of otoliths samples collected by TIP agents and read (for determination of age) by the Panama City Laboratory from 1984 to 2005.

Year	Number of samples	Number of otolith collected	Percent of otolith collected	Number of otolith in PC database	Number of otolith read	Percent of otolith read
1984	2711					
1985	5310					
1986	7532	3	0.04%			
1987	4639					
1988	2560					
1989	2810					
1990	12204					
1991	14864	126	0.85%	96	82	0.55%
1992	11692	209	1.79%	214	197	1.68%
1993	12692	377	2.97%	378	376	2.96%
1994	11682	412	3.53%	359	356	3.05%
1995	14737	398	2.70%	394	359	2.44%
1996	13508	253	1.87%	213	195	1.44%
1997	17642	75	0.43%	67	60	0.34%
1998	33508	191	0.57%	173	168	0.50%
1999	52918	754	1.42%	770	751	1.42%
2000	40789	648	1.59%	669	655	1.61%
2001	30933	1732	5.60%	1843	1807	5.84%
2002	25803	2121	8.22%	2144	1402	5.43%
2003	18056	3001	16.62%	3003	1657	9.18%
2004	14297	2961	20.71%	2972	1781	12.46%
2005	10140	3597	35.47%	3619	1634	16.11%

Table 7. Percent of TIP sampling trips from which otoliths were collected, and percent of trips from which otoliths were collected and read (for determination of age).

Year	Number of trip	Number of trip with otolith collected	Percent of trips with otolith collected	Number of trip with otolith read	Percent of trips with otolith read
1984	68				
1985	95				
1986	154	2	1.30%		
1987	103				
1988	47				
1989	50				
1990	150				
1991	200	25	12.50%	20	10.00%
1992	190	23	12.11%	19	10.00%
1993	264	52	19.70%	51	19.32%
1994	279	46	16.49%	45	16.13%
1995	288	55	19.10%	55	19.10%
1996	292	27	9.25%	31	10.62%
1997	318	15	4.72%	9	2.83%
1998	507	32	6.31%	26	5.13%
1999	561	91	16.22%	88	15.69%
2000	504	68	13.49%	69	13.69%
2001	513	148	28.85%	157	30.60%
2002	521	215	41.27%	205	39.35%
2003	575	332	57.74%	291	50.61%
2004	497	329	66.20%	305	61.37%
2005	450	326	72.44%	227	50.44%

Table 8. Percent of trips and red grouper otolith samples that had otolith sample sizes less than 5 from 1984 to 2004 (oss - otolith sample size).

Year	Number of trips with oss > 0	Number of trips with oss <=5	Percent of trips with oss <=5	Number of otolith collected	Number of otolith with oss <=5	Percent of otolith with oss <=5
1991	25	20	80.00%	126	48	38.10%
1992	23	13	56.52%	209	33	15.79%
1993	52	29	55.77%	377	59	15.65%
1994	46	23	50.00%	412	76	18.45%
1995	55	30	54.55%	398	76	19.10%
1996	27	11	40.74%	253	24	9.49%
1997	15	10	66.67%	75	17	22.67%
1998	32	18	56.25%	191	50	26.18%
1999	91	28	30.77%	754	91	12.07%
2000	68	22	32.35%	648	64	9.88%
2001	148	65	43.92%	1732	150	8.66%
2002	215	114	53.02%	2121	254	11.98%
2003	332	187	56.33%	3001	434	14.46%
2004	329	155	47.11%	2961	396	13.37%
2005	326	141	43.25%	3597	311	8.65%

*

Table 9. Percent of trips and red grouper otolith samples that had otolith sample sizes less than 10 from 1984 to 2004.

Year	Number of trips with oss > 0	Number of trips with oss <=10	Percent of trips with oss <=10	Number of otolith collected	Number of otolith with oss <=10	Percent of otolith with oss <=10
1991	25	22	88.00%	126	62	49.21%
1992	23	18	78.26%	209	74	35.41%
1993	52	36	69.23%	377	113	29.97%
1994	46	39	84.78%	412	201	48.79%
1995	55	43	78.18%	398	172	43.22%
1996	27	20	74.07%	253	99	39.13%
1997	15	13	86.67%	75	38	50.67%
1998	32	28	87.50%	191	137	71.73%
1999	91	70	76.92%	754	456	60.48%
2000	68	45	66.18%	648	249	38.43%
2001	148	84	56.76%	1732	302	17.44%
2002	215	142	66.05%	2121	478	22.54%
2003	332	223	67.17%	3001	715	23.83%
2004	329	222	67.48%	2961	917	30.97%
2005	326	197	60.43%	3597	756	21.02%

Table 10. Numbers of red grouper otolith samples collected from each gear type, and number of otoliths being read (for determination of age) from 1984 to 2005.

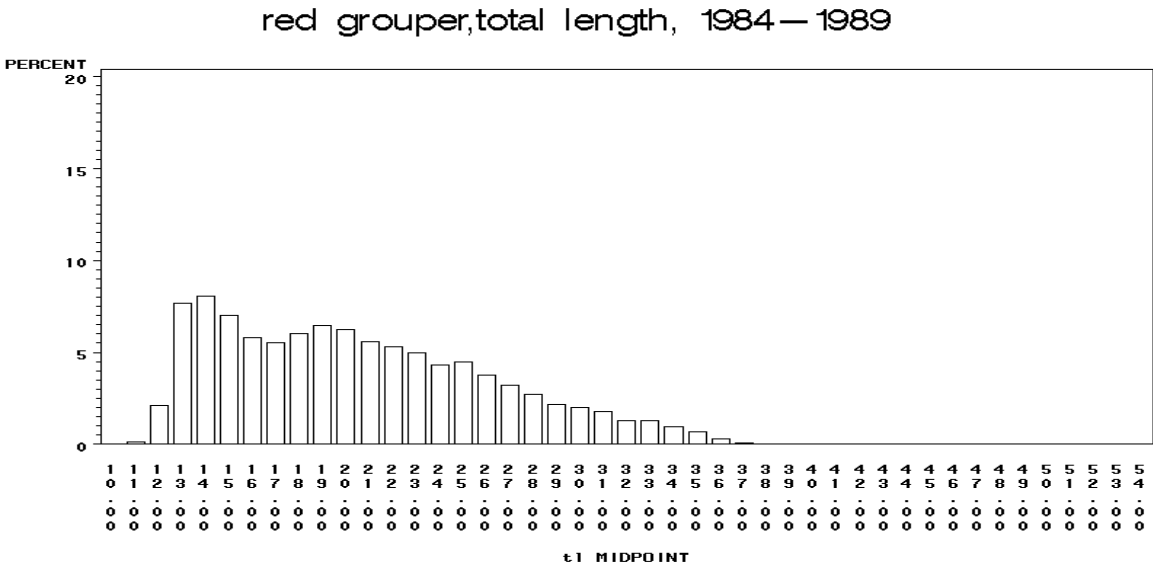
Year	Otolith collected	Otolith collected	Otolith collected	Otolith read /Handline	Otolith read /Longline	Otolith read /Trap
1984						
1985						
1986	1	2				
1987						
1988						
1989						
1990						
1991	73	58	2	43	37	2
1992	107	148	15	42	141	14
1993	189	195	91	92	200	84
1994	400	88	29	239	88	29
1995	230	152	46	180	140	39
1996	234	112	9	85	96	8
1997	137	8	17	35	7	17
1998	135	112	36	26	109	33
1999	119	629	31	77	643	31
2000	211	396	38	206	405	38
2001	362	1345	31	555	1210	39
2002	240	1805	91	249	1063	89
2003	565	2386	60	527	1061	65
2004	747	2186	20	726	1017	36
2005	573	3002	2	526	1104	0

Table 11 - Number of otolith samples read (for determination of age) at selected length intervals (note: each interval has a range of 1 inch; for example, a length interval at 20 inches means 19.5 inches <=length < 20.5 inches)

Year	Length interval <20	Length interval =20	Length interval =25	Length interval =30	Length interval =35	Length interval >35
1991	3	3	2	9	9	
1992	0	9	12	14	14	
1993	11	36	28	19	19	
1994	39	53	25	9	9	3
1995	15	43	23	13	13	2
1996	9	23	9	8	8	
1997	6	6	6	5	5	
1998	4	26	13	1	1	
1999	13	55	77	26	26	
2000	15	52	51	33	33	
2001	49	191	119	59	59	5
2002	35	142	78	50	50	6
2003	72	178	108	65	65	9
2004	17	128	137	89	89	15
2005	53	169	139	37	37	4

Fig 1. Length frequency distributions for red groupers caught in the Gulf of Mexico (a) from 1984 to 1989 and (b) from 1990 to 2005.

(a).



(b).

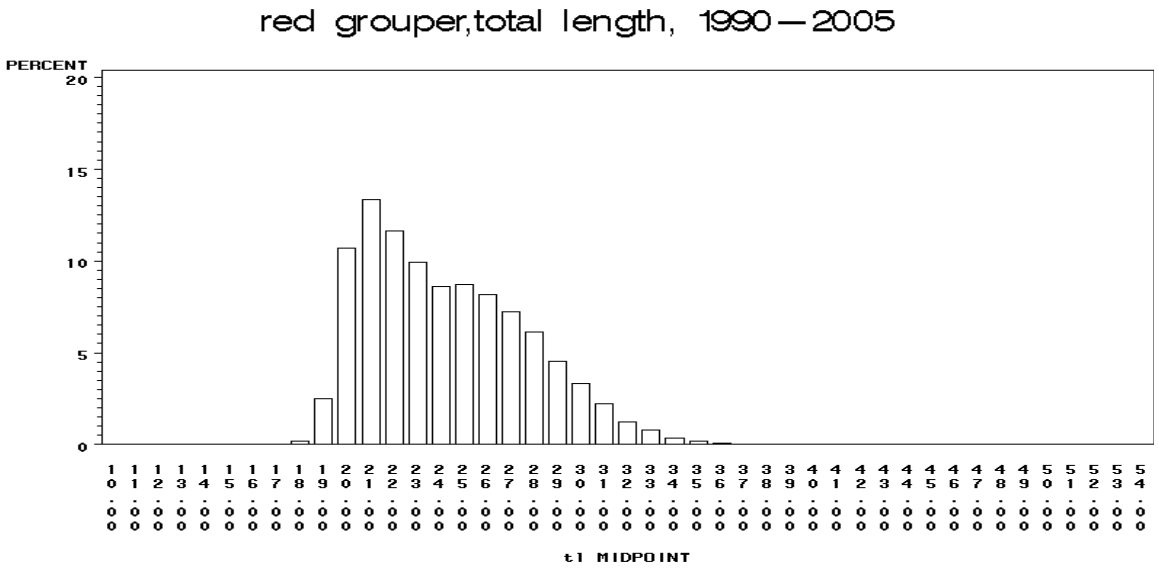
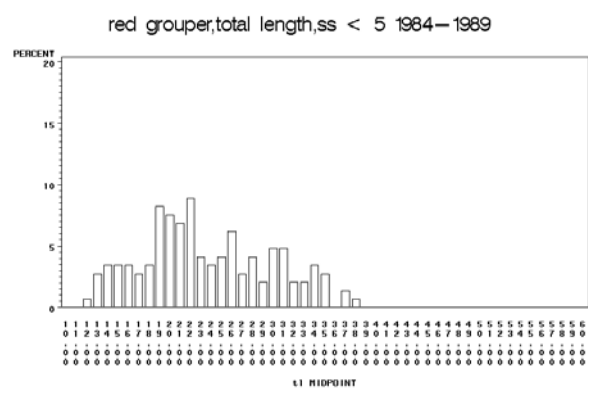
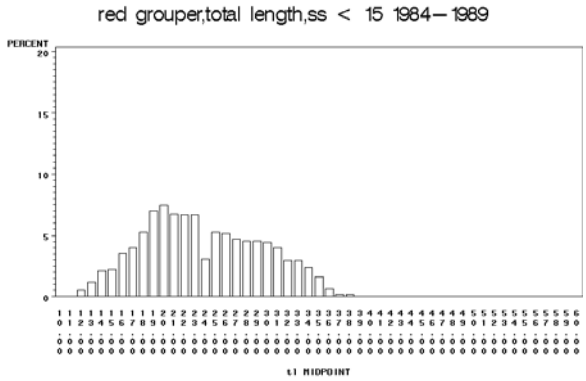
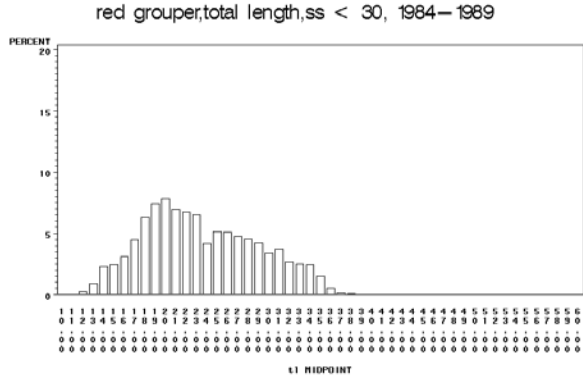
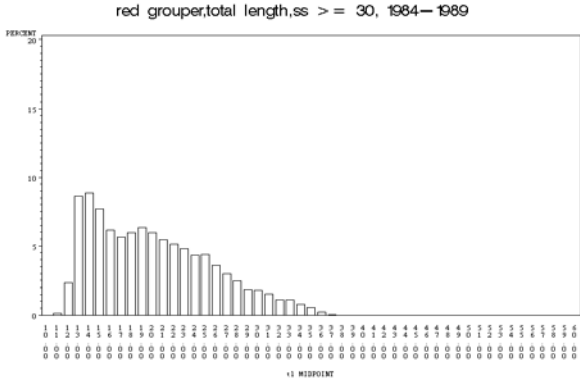


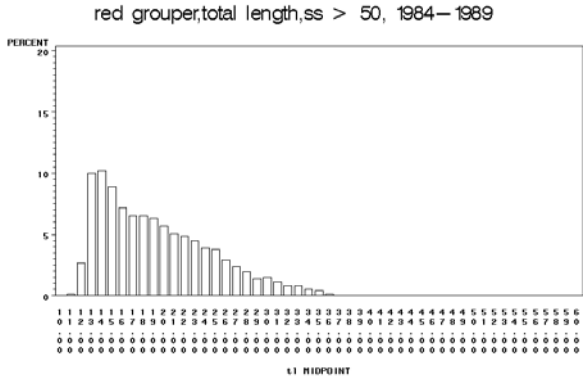
Fig 2. Length frequency distributions for red groupers with different sample sizes taken from commercial landings during the years 1984-1989 (ss- sample size for individual trips).











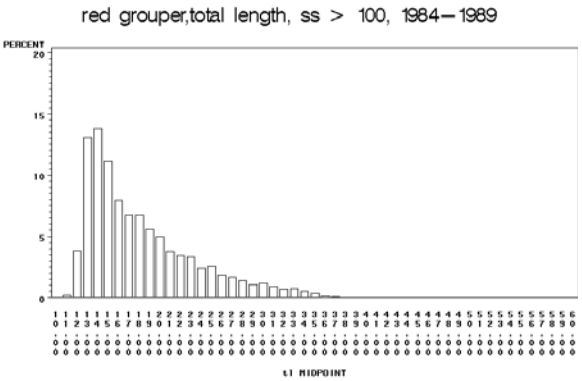
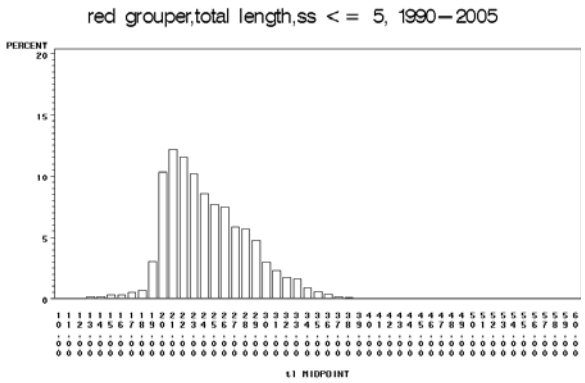
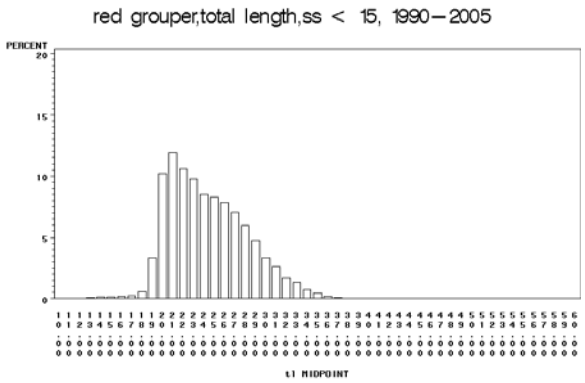
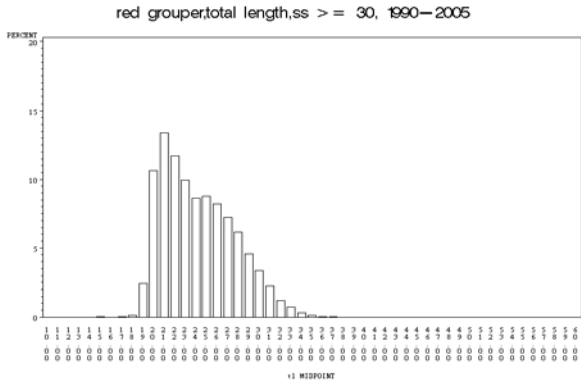
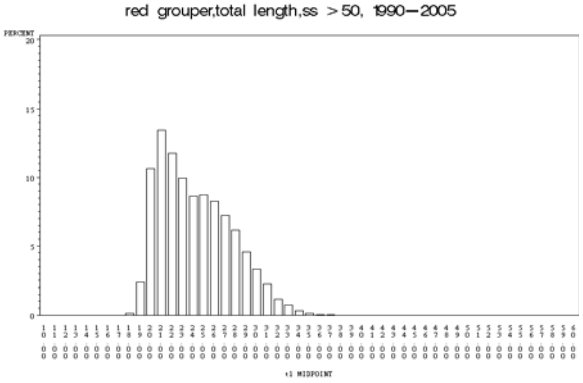


Fig 3. Length frequency distributions for red groupers with different sample sizes taken from commercial landings during the years 1990-2005 (ss- sample size for individual trips).









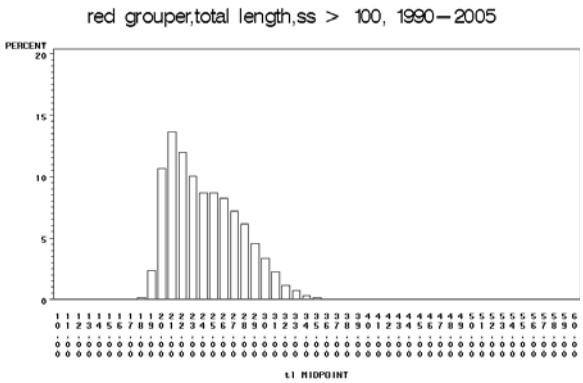
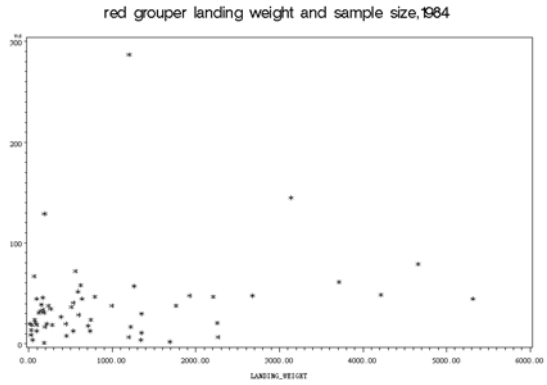
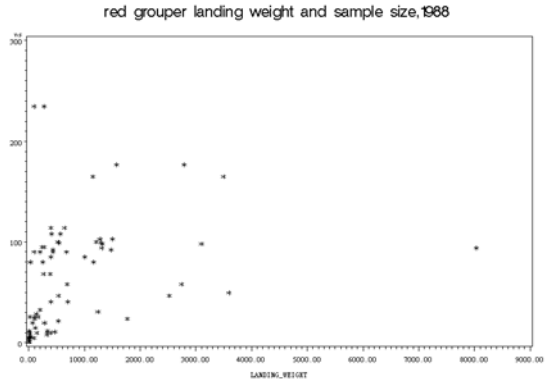
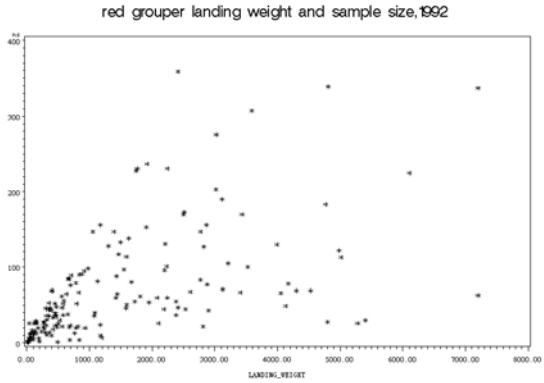
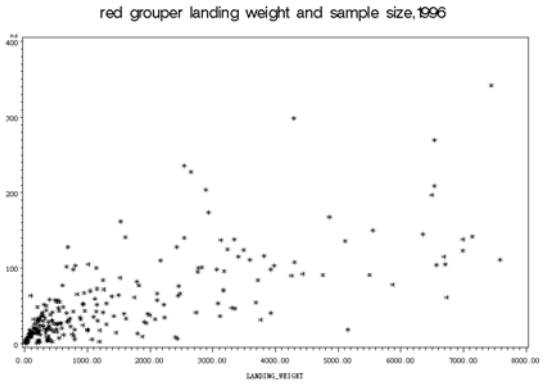


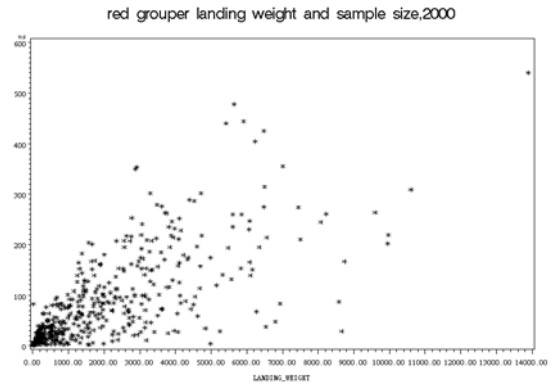
Fig 4. The relationship of landing weight to sample size in red grouper TIP samples for selected years (ns- sample size for individual trip).











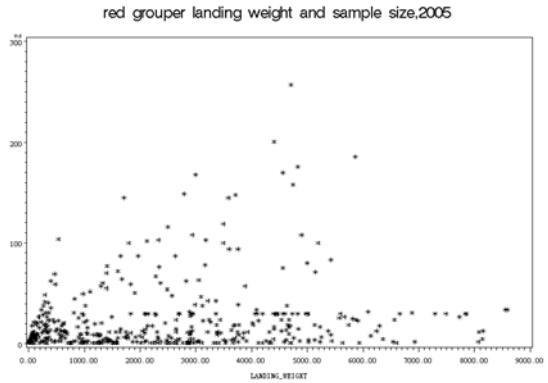
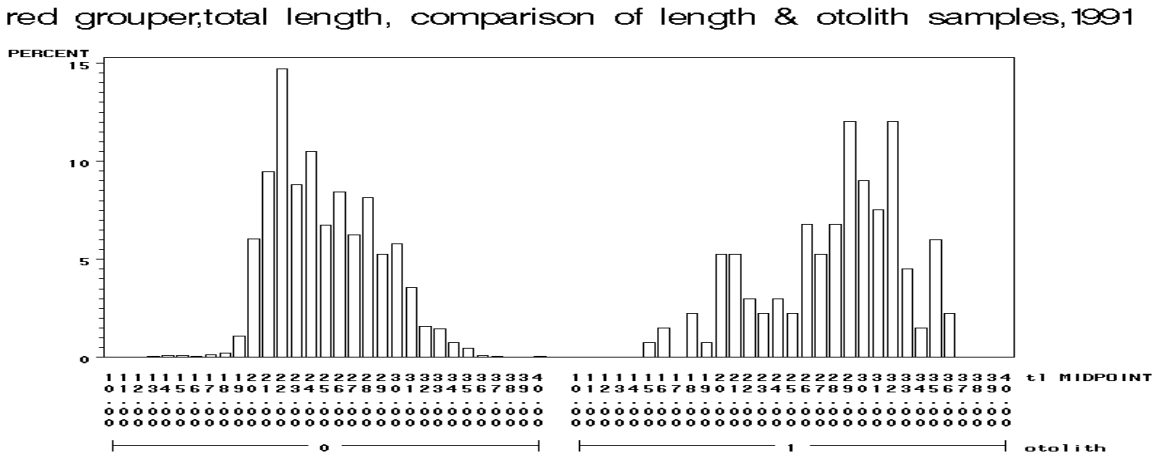
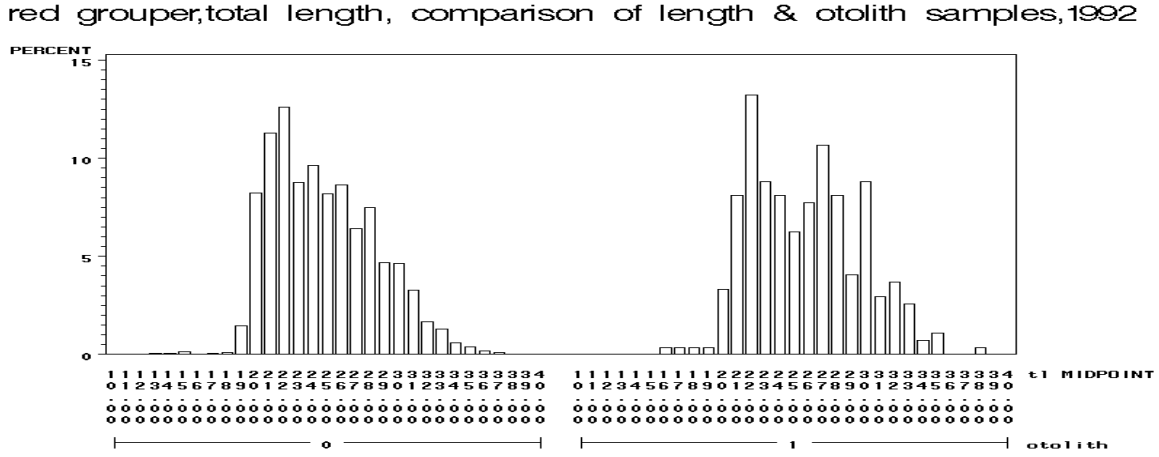


Fig 5. Comparison of red grouper length and otolith samples from commercial landings in the Gulf of Mexico from 1991 to 2005 (otolith 1- otolith sample, 0-length sample; see Table 6 for number of samples, otolith records based on TIP database).





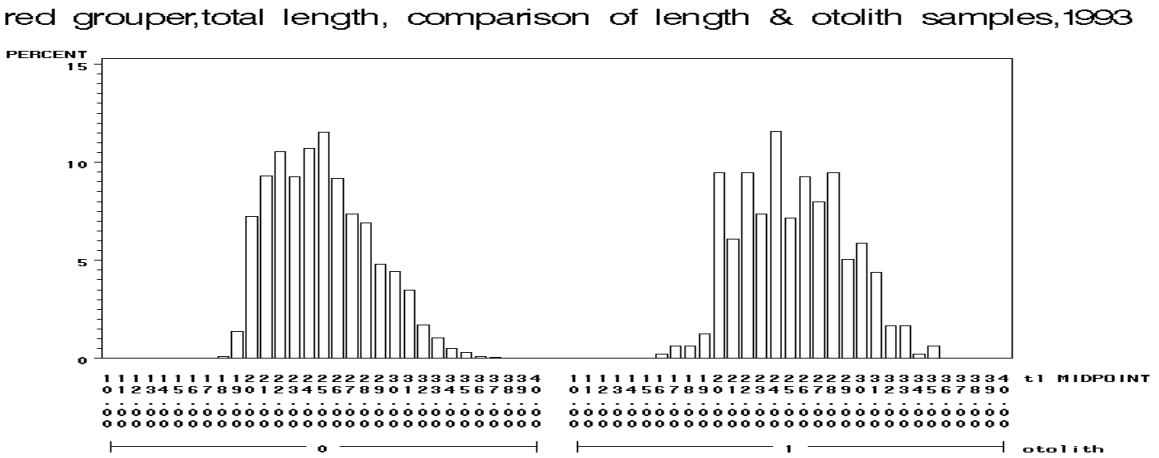
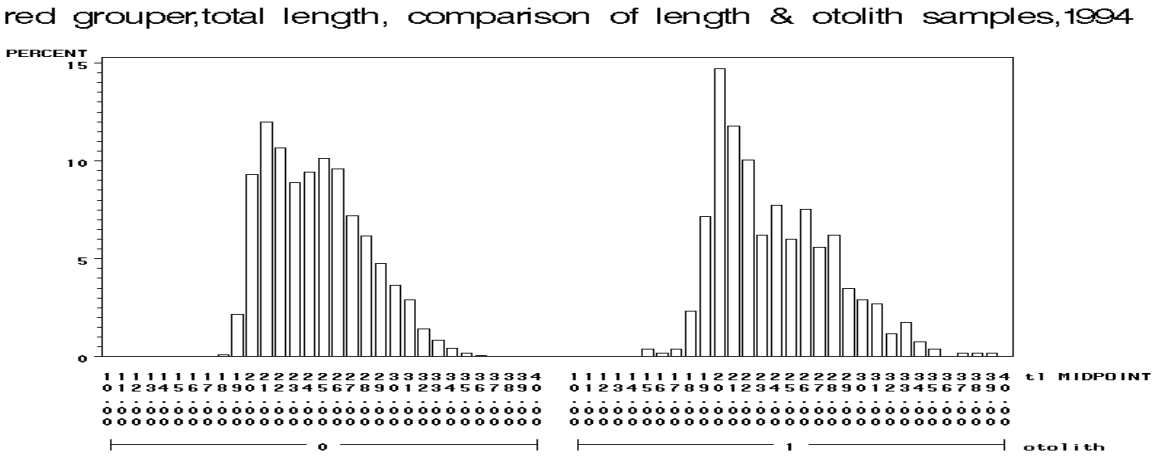
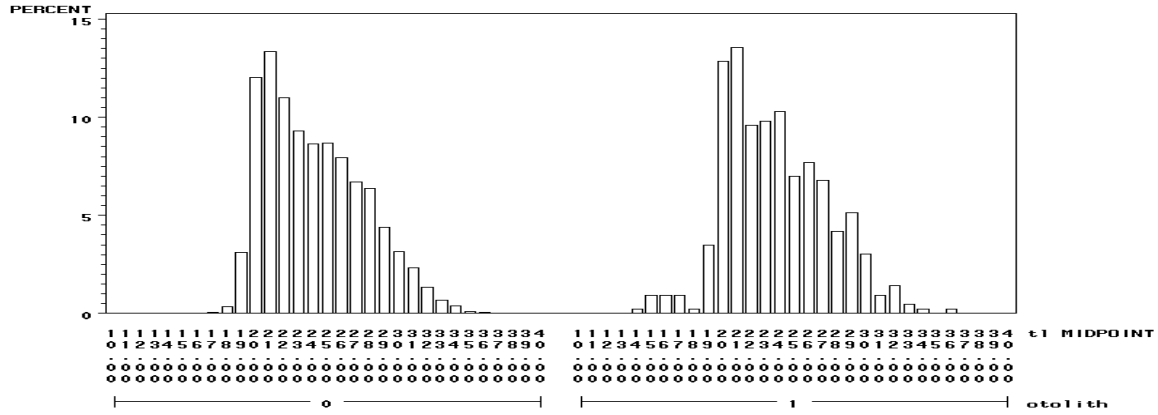


Fig 5 -continued.





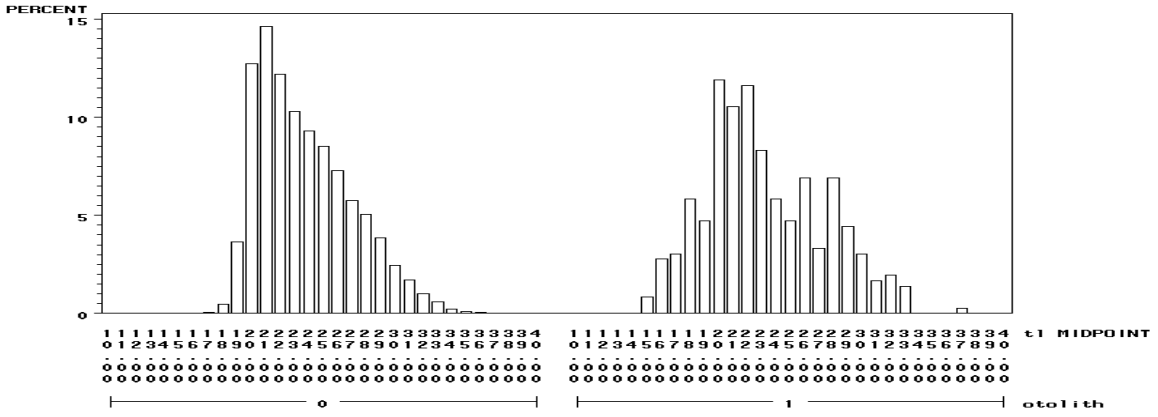
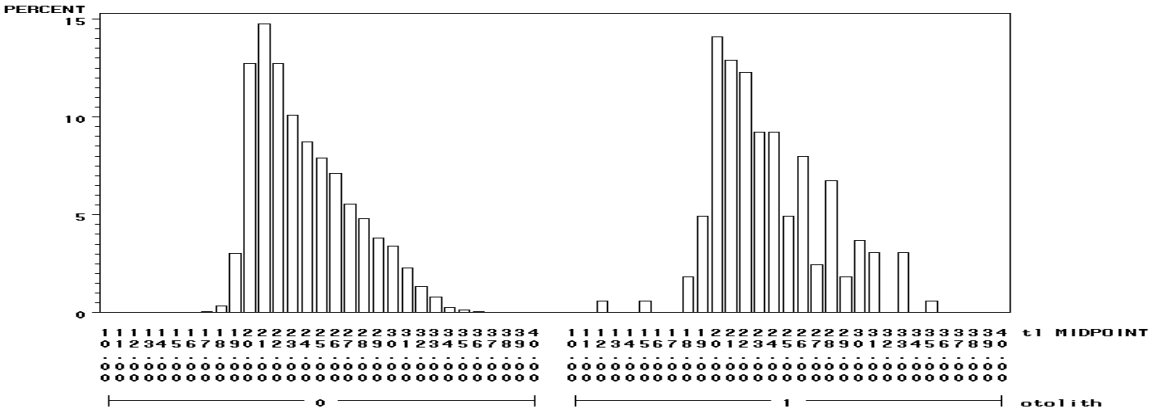
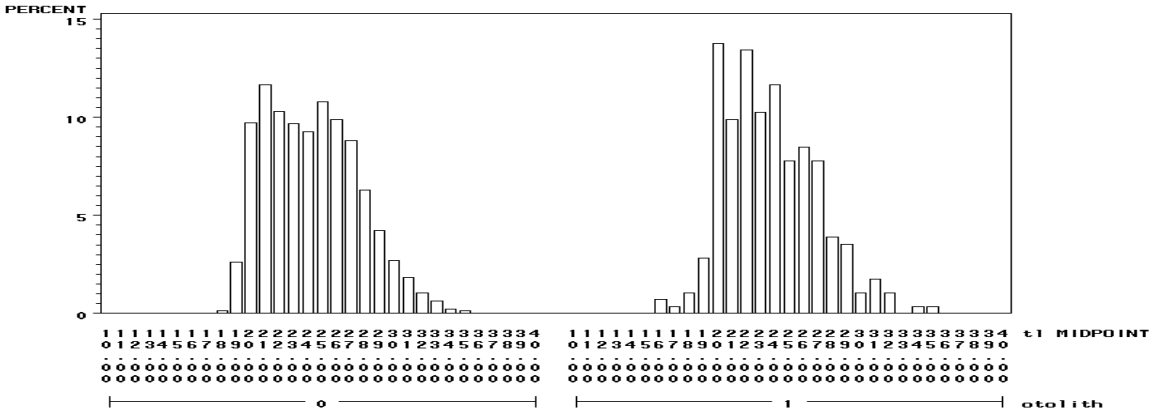


Fig 5 - continued.

red grouper,total length, comparison of length & otolith samples,1997



red grouper,total length, comparison of length & otolith samples,1998



red grouper,total length, comparison of length & otolith samples,1999

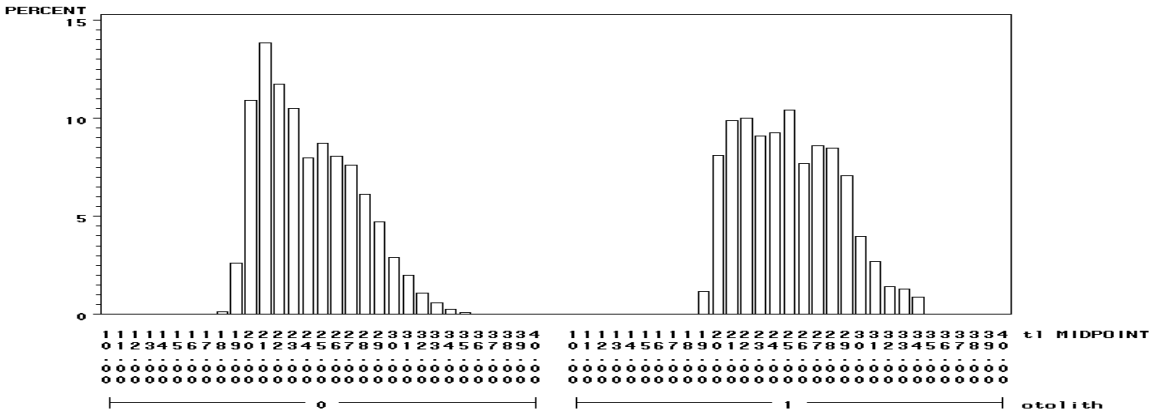
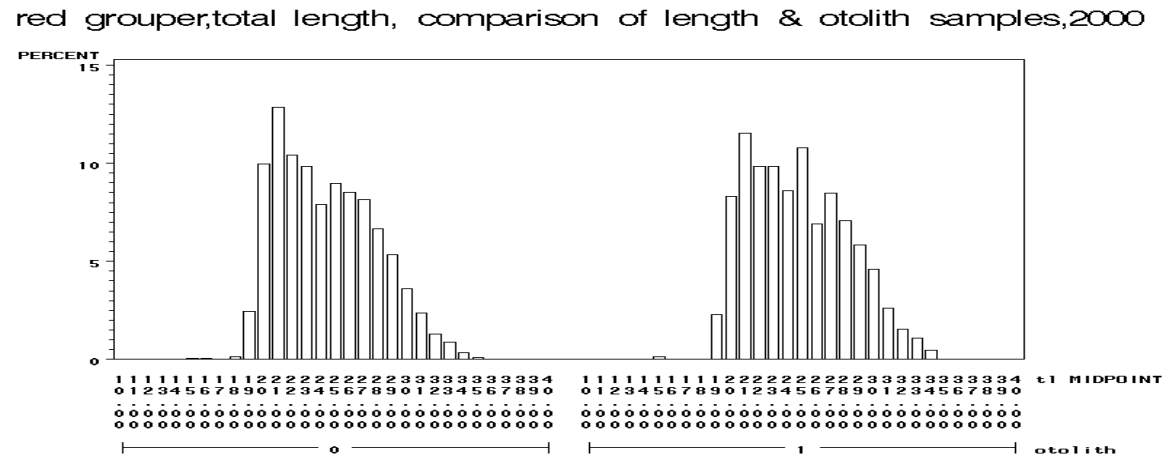
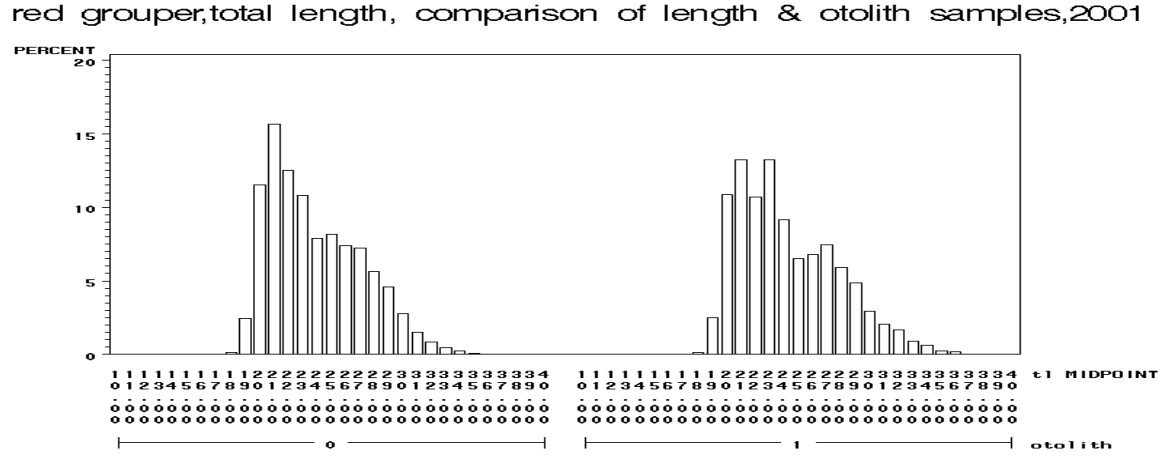


Fig 5 - continued.





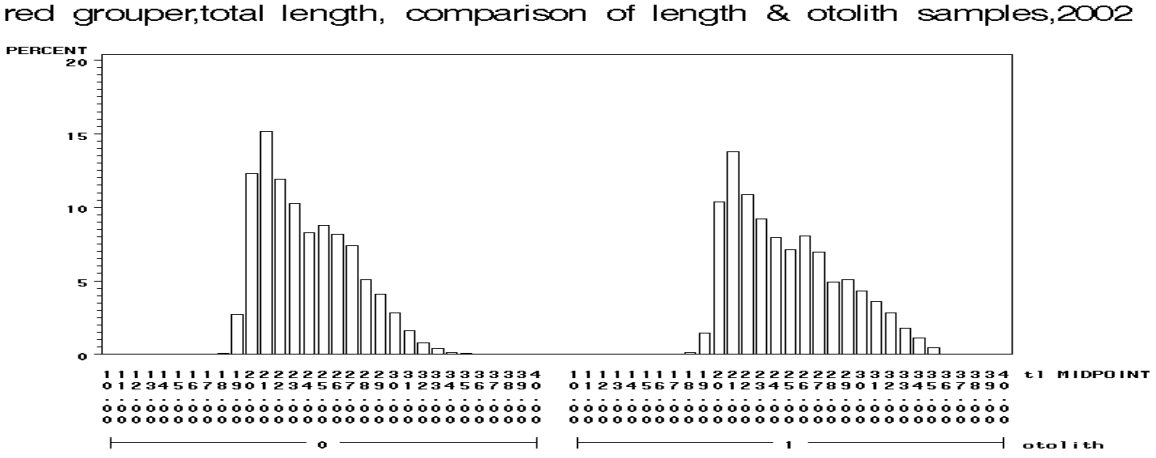
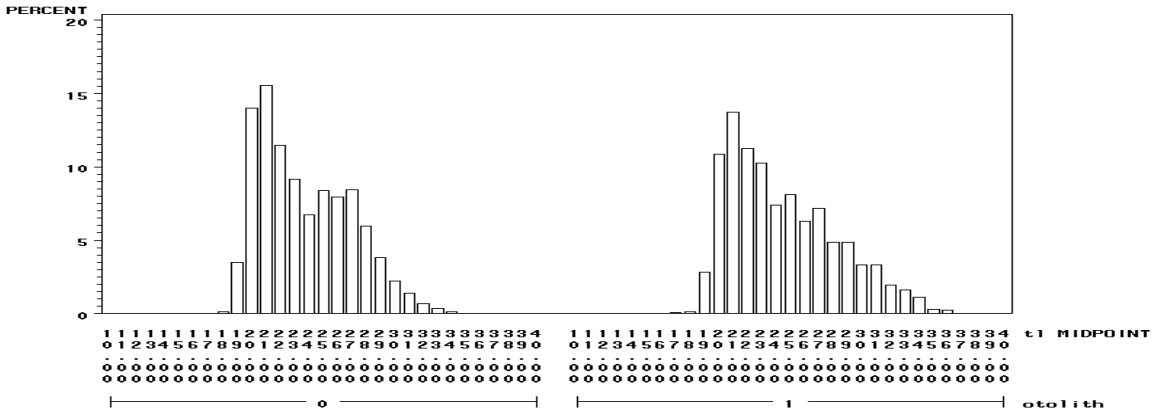
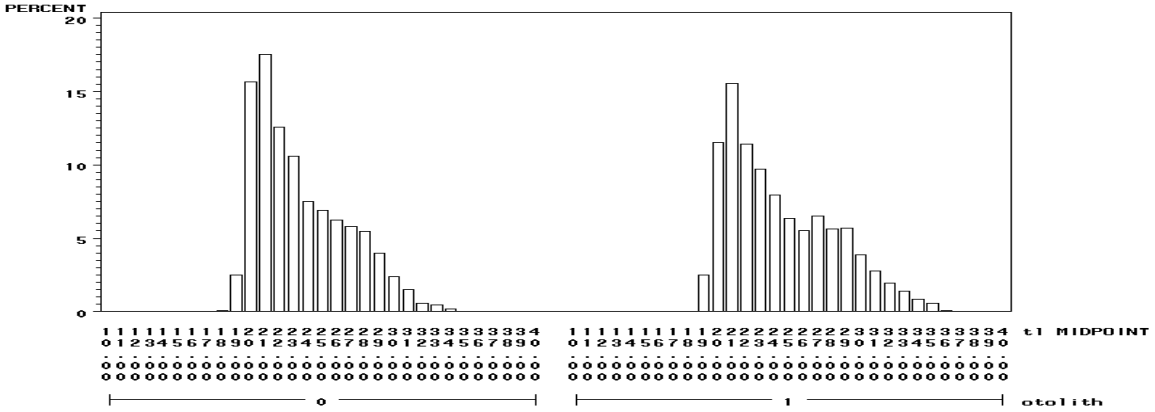


Fig 5 - continued.

red grouper,total length, comparison of length & otolith samples,2003



red grouper,total length, comparison of length & otolith samples,2004



red grouper,total length, comparison of length & otolith samples,2005

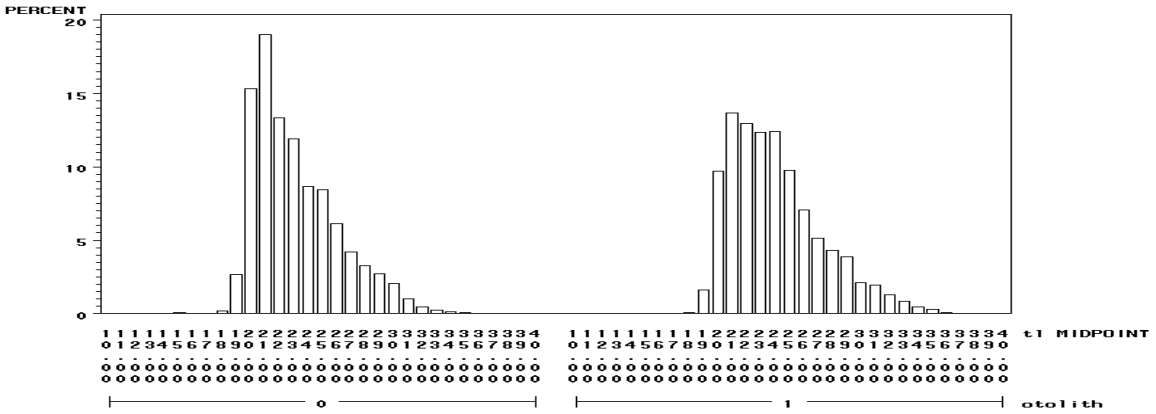
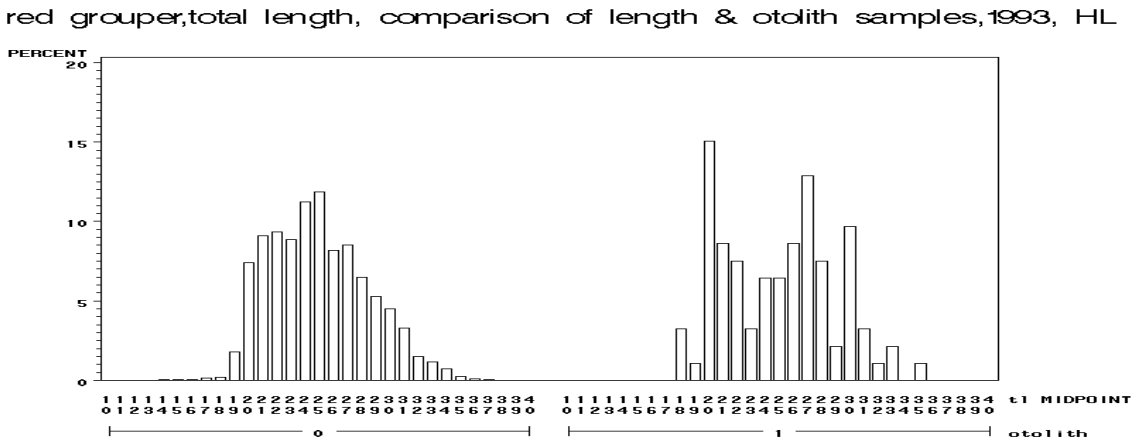
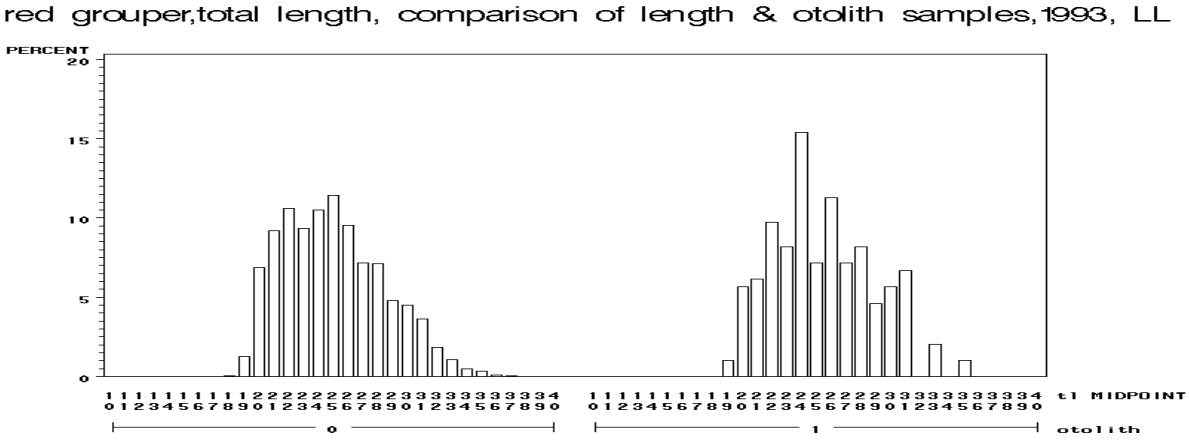


Fig 6. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 1993 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).





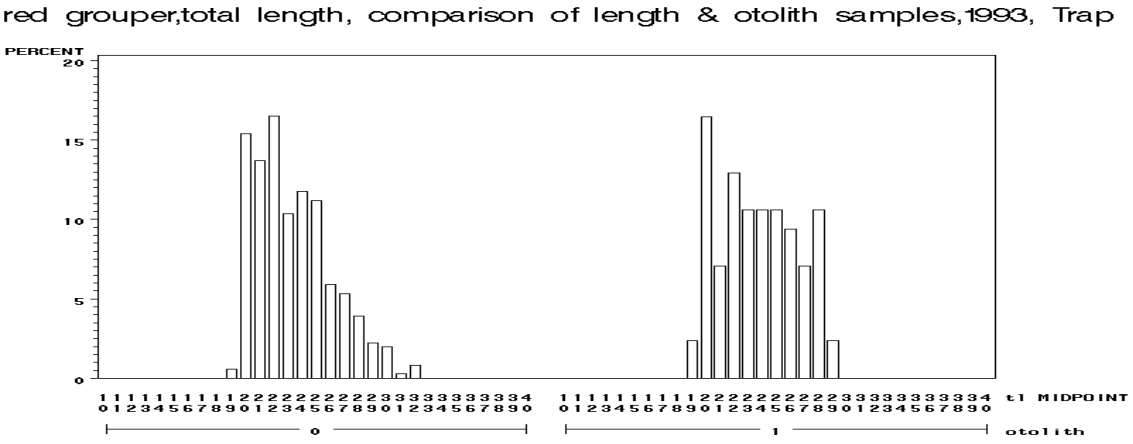
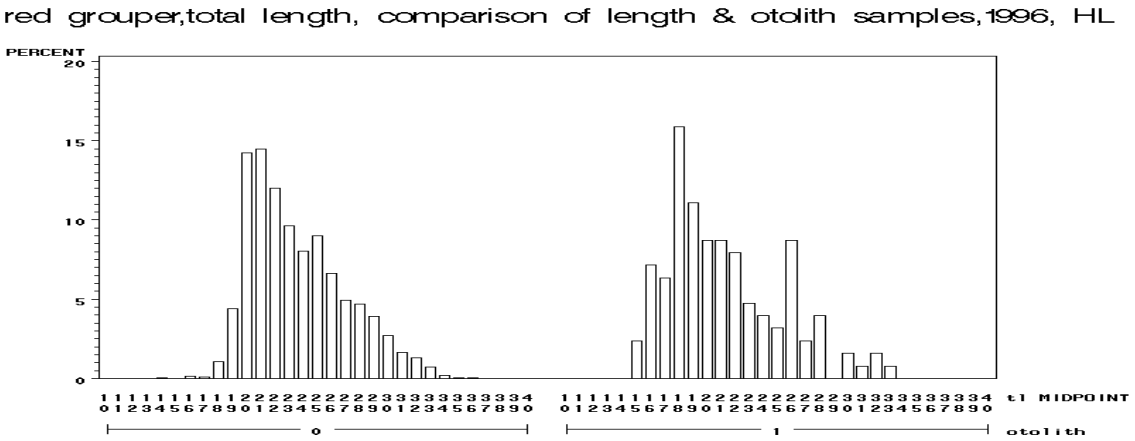
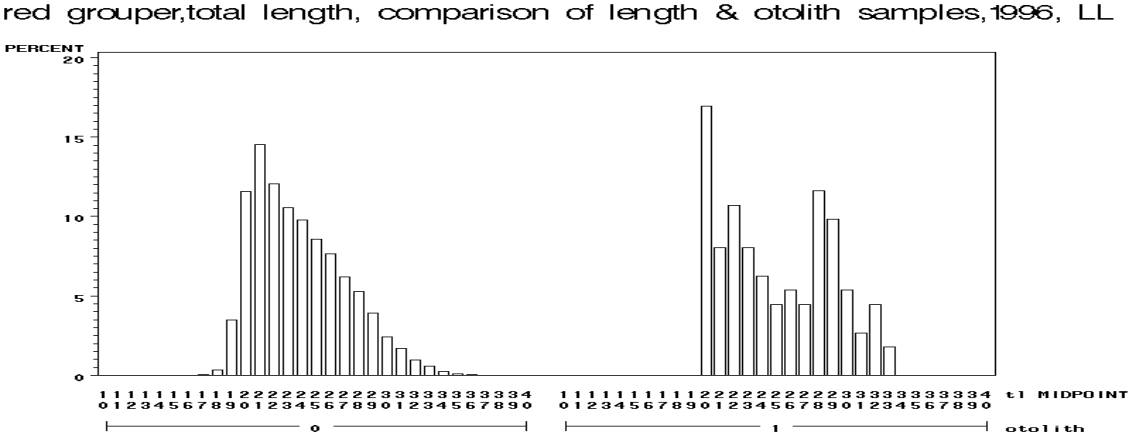


Fig 7. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 1996 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).





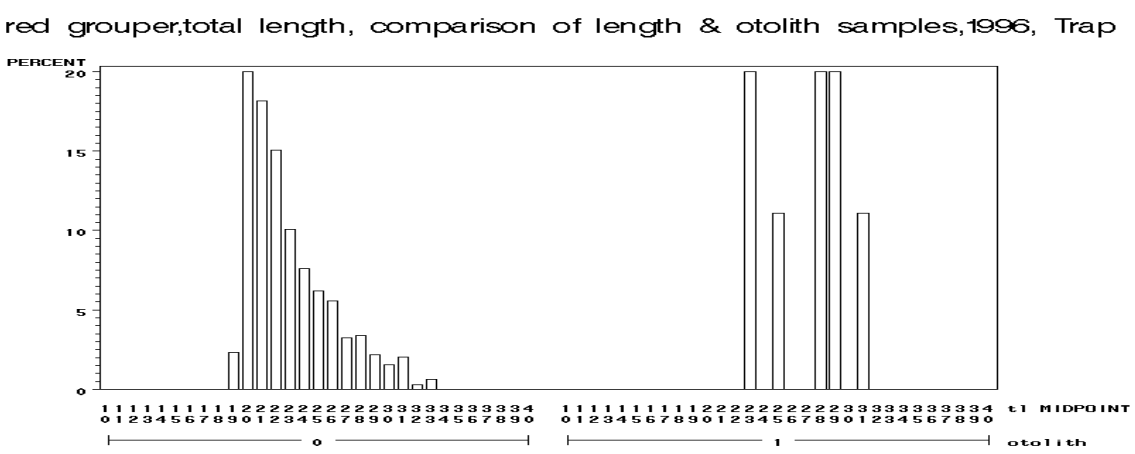
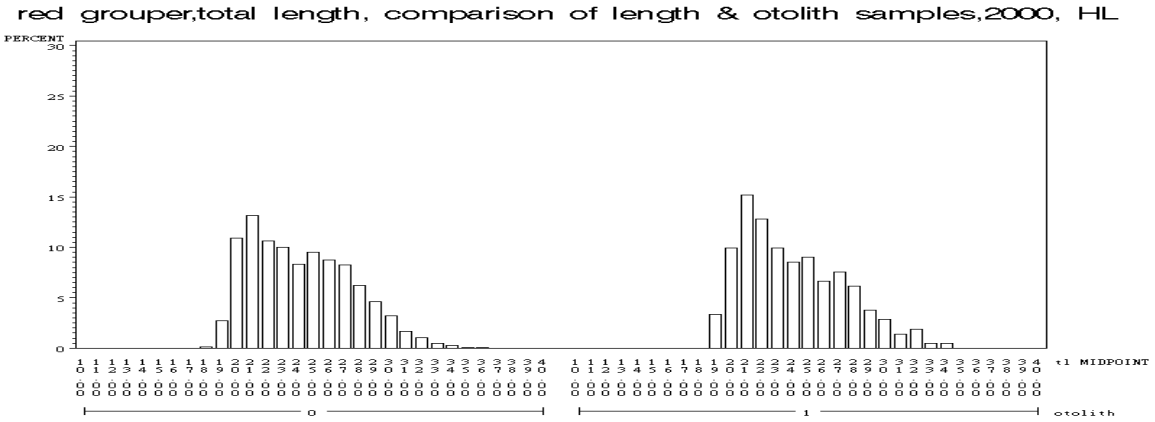
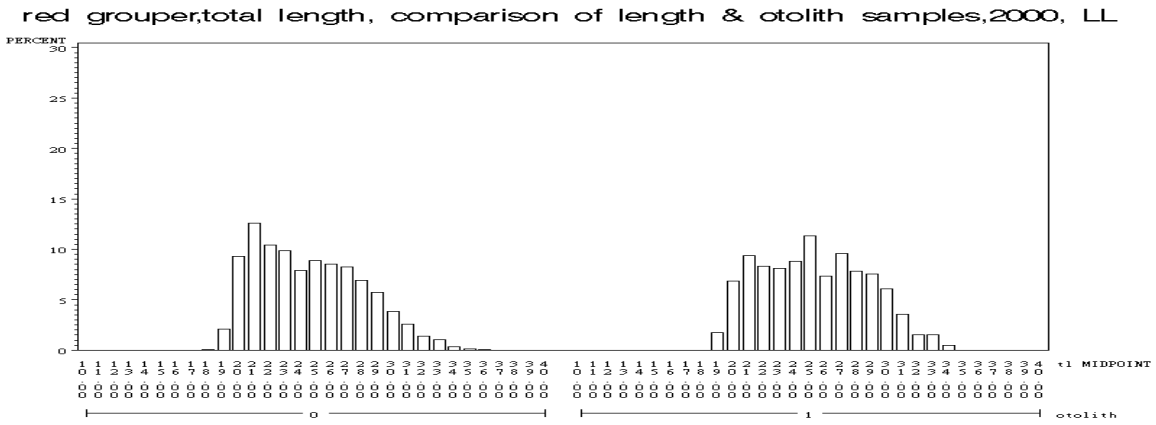


Fig 8. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 2000 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).





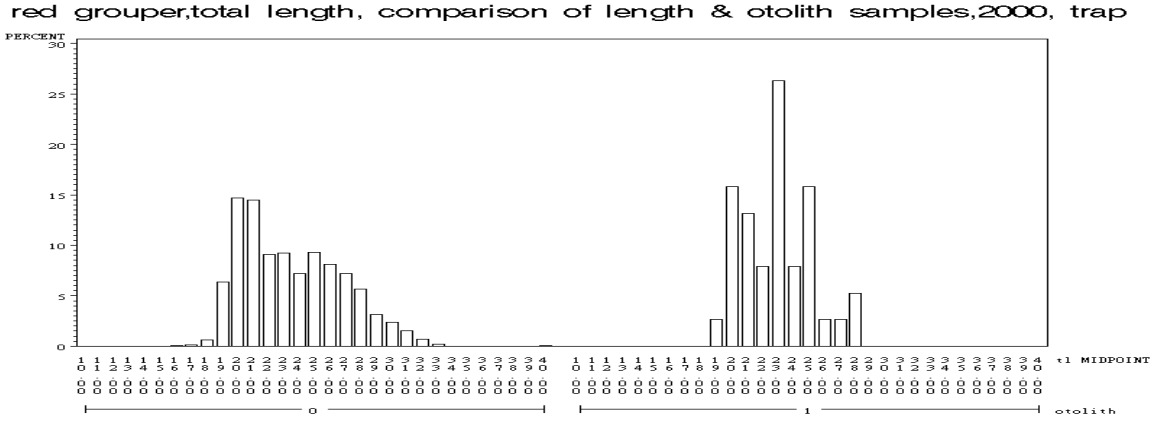
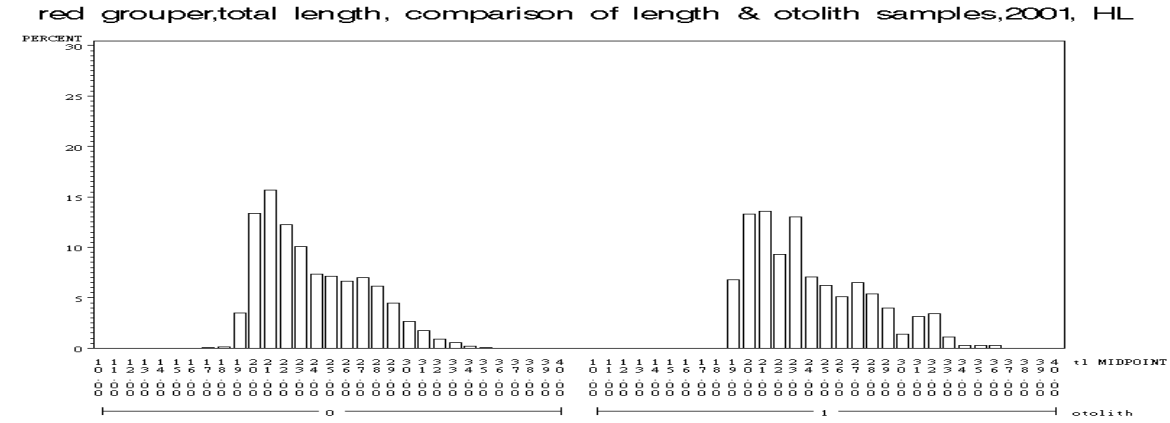
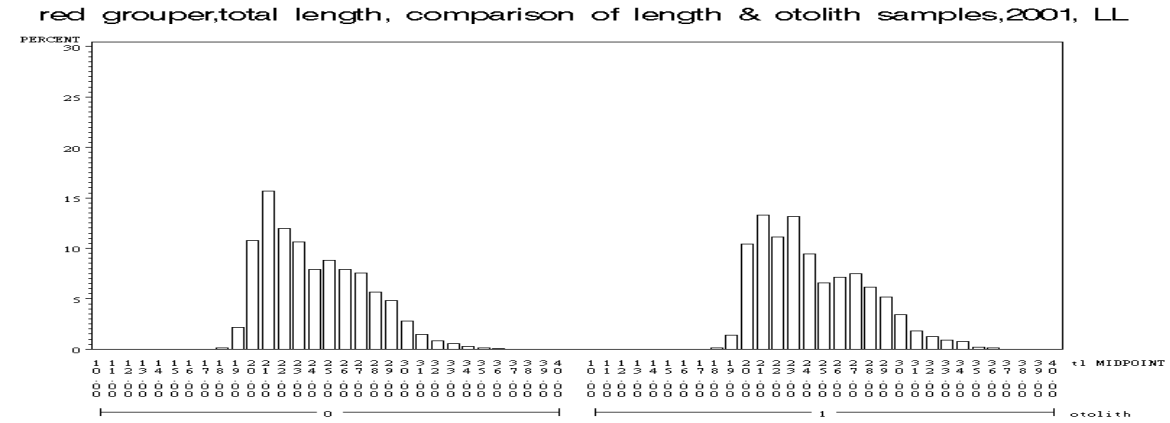


Fig 9. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 2001 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).





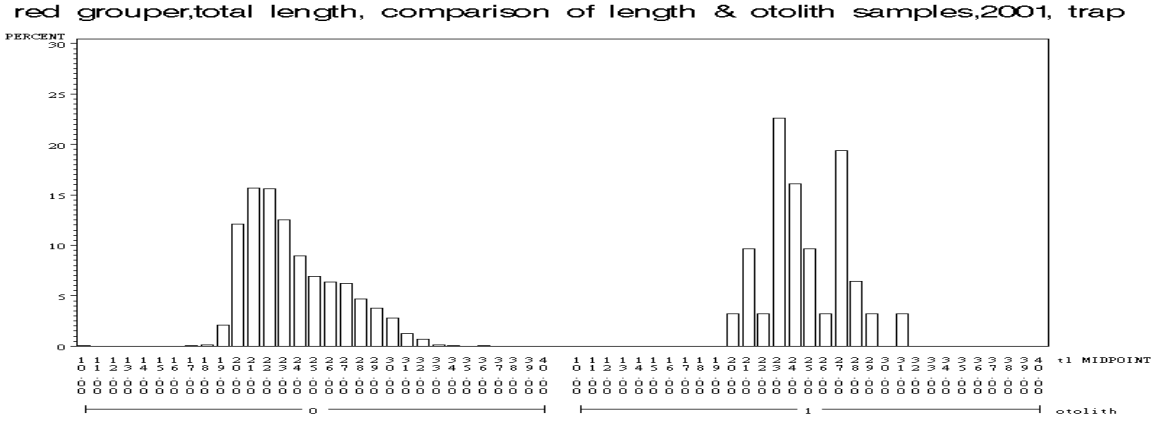
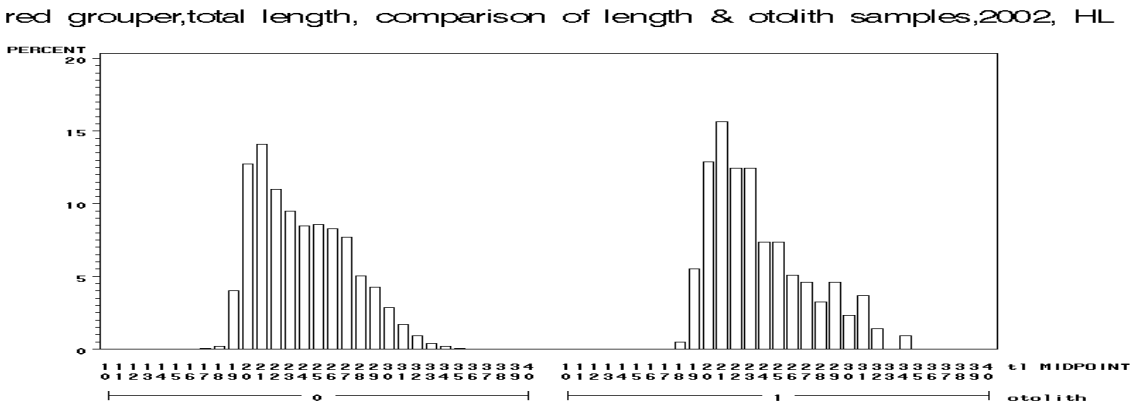
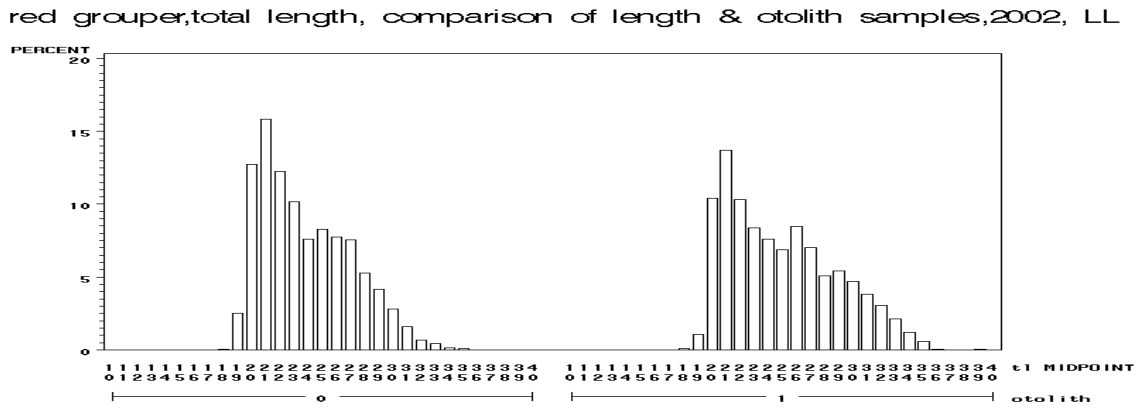


Fig 10. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 2002 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).





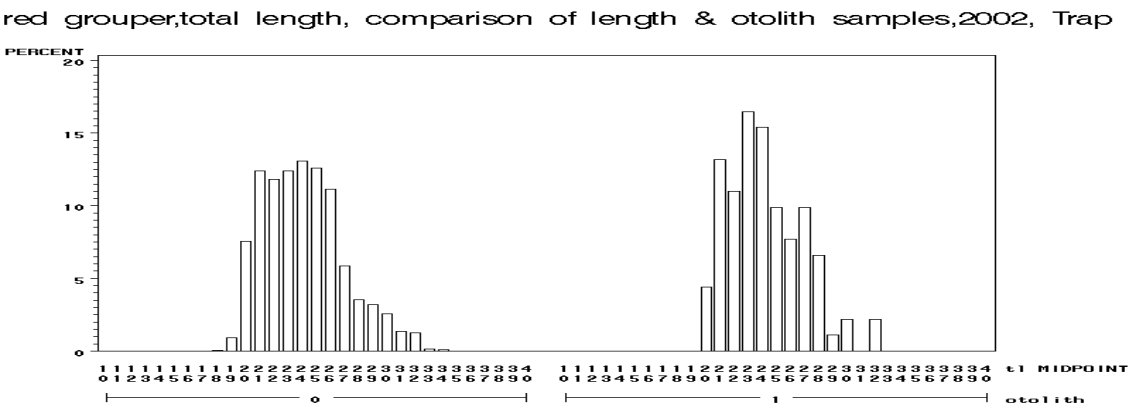
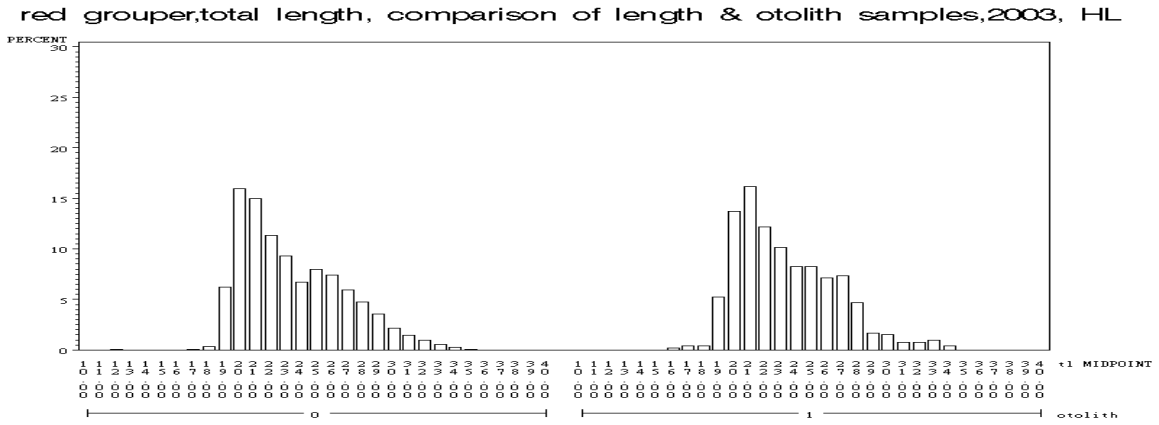
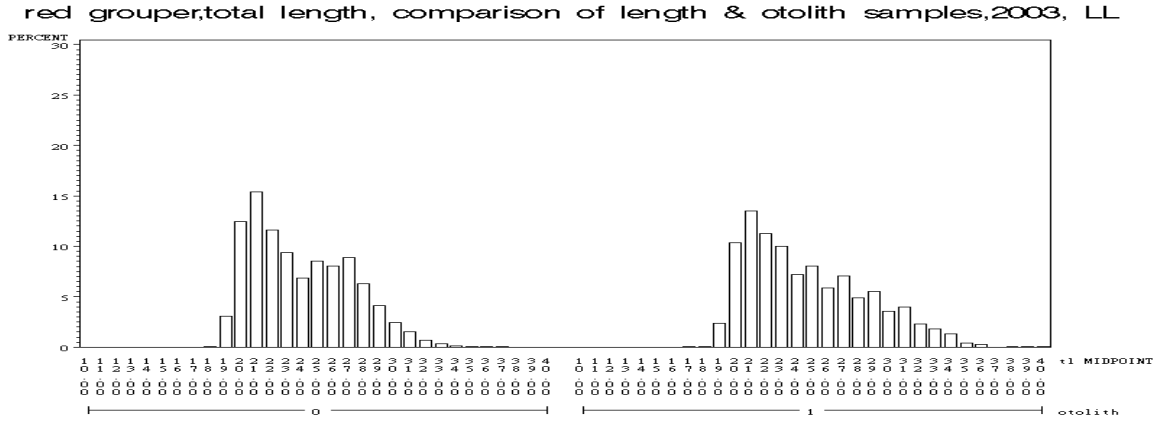


Fig 11. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 2003 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).





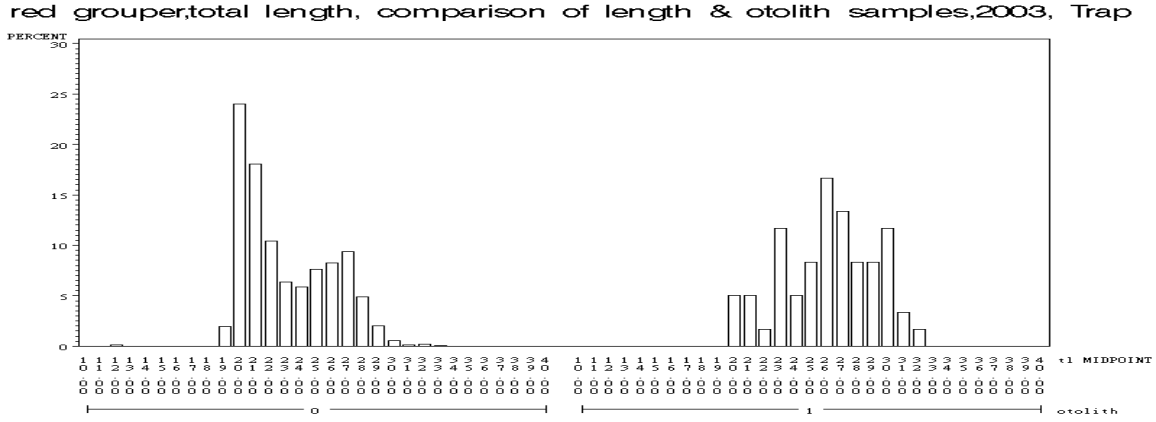
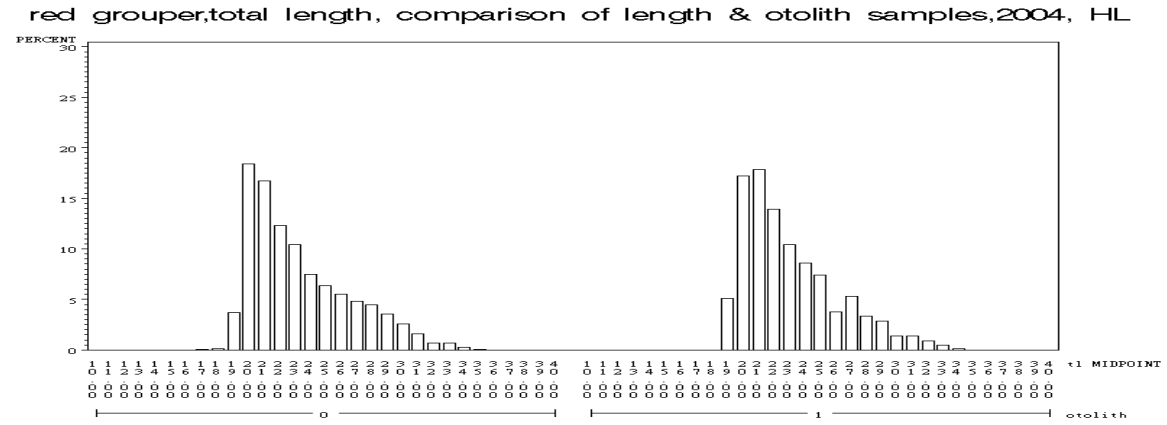
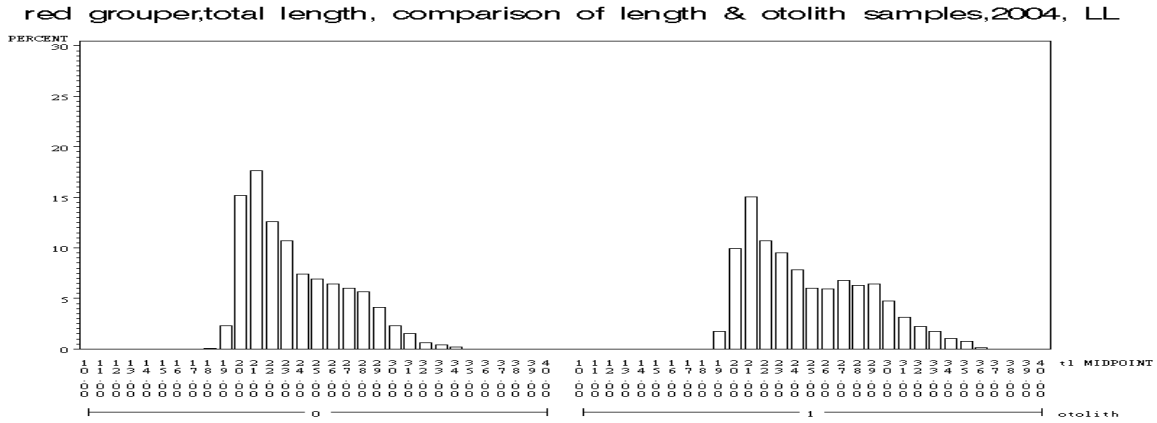


Fig 12. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 2004 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).





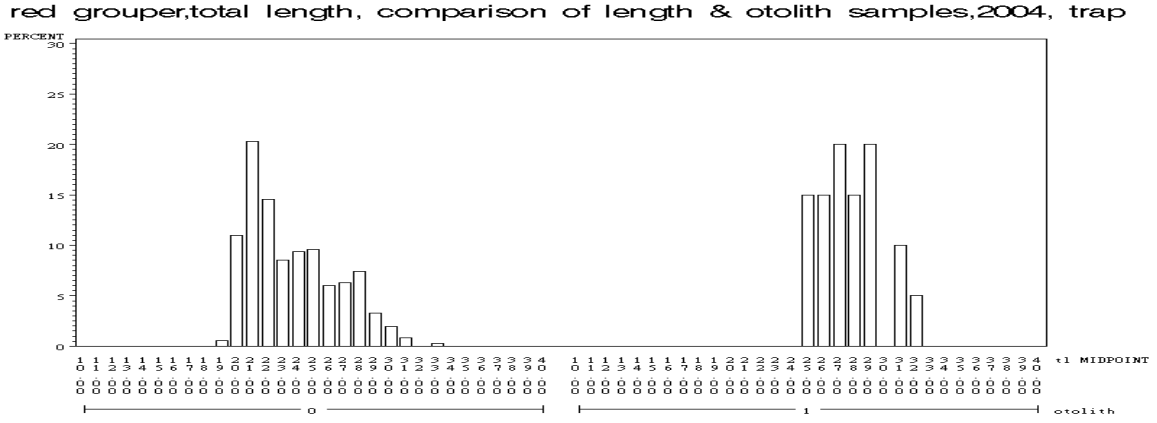
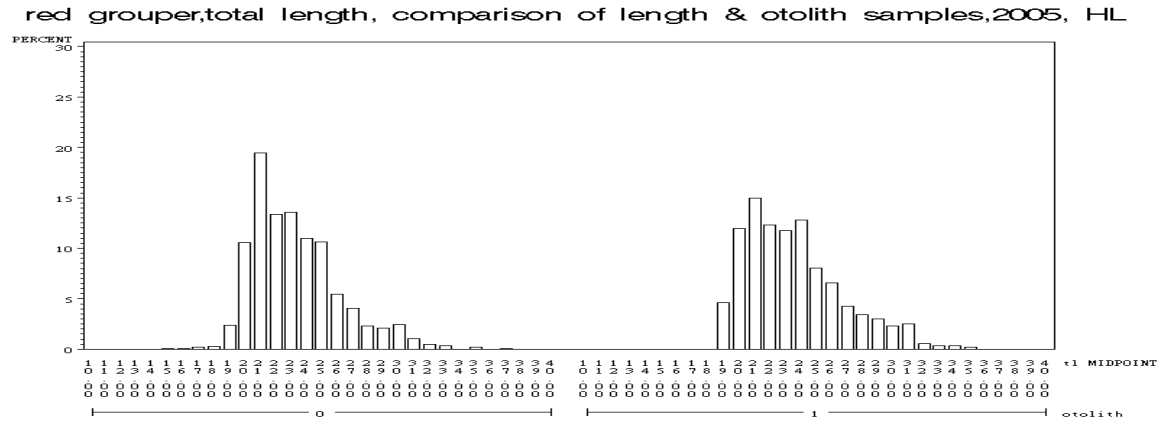


Fig 13. Comparison of red grouper length and otolith samples taken from handline (HL), longline (LL) and trap fisheries in the Gulf of Mexico during 2005 (otolith 1- otolith sample, 0-length sample, see Table 10 for number of samples).



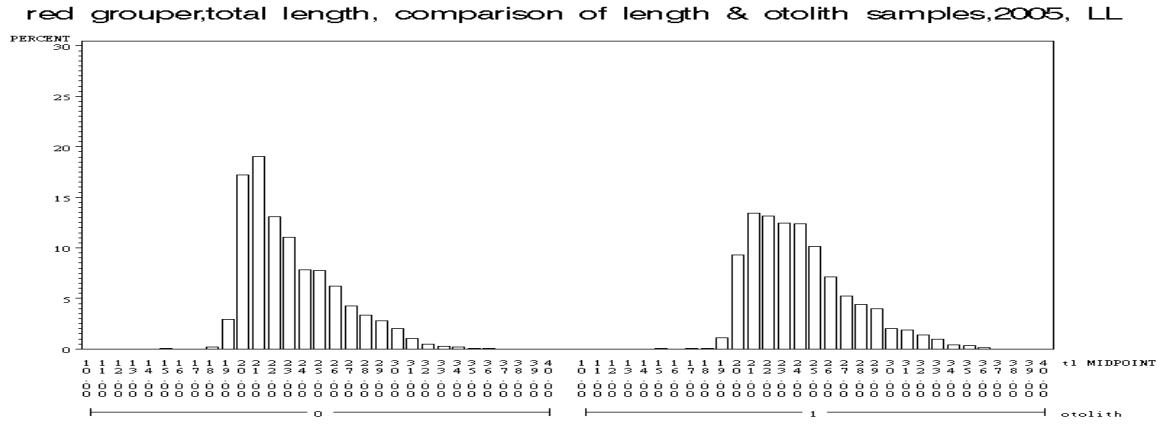
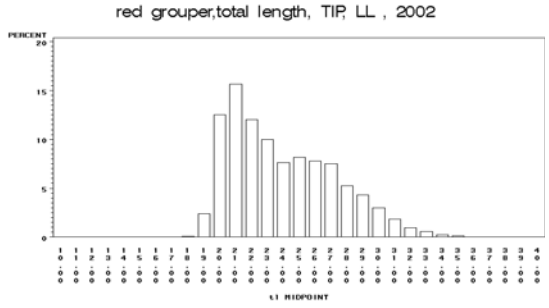
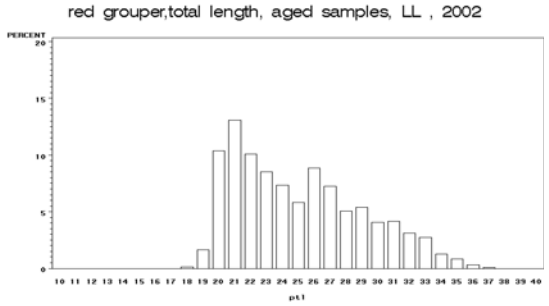
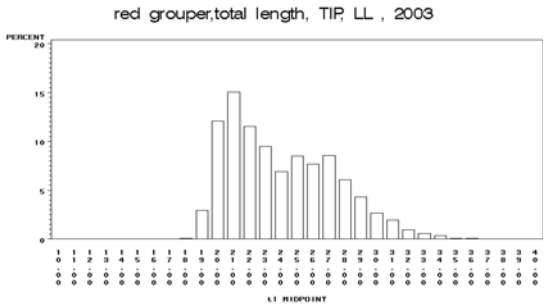
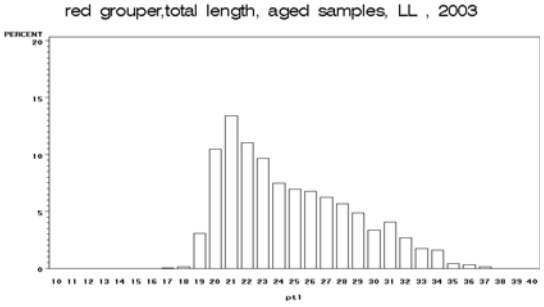


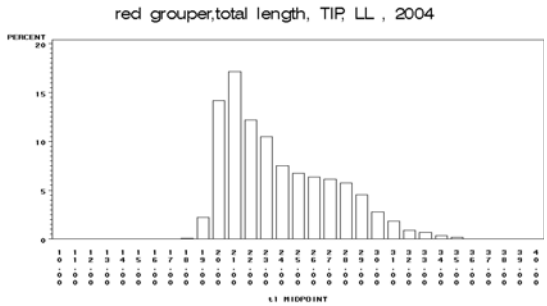
Fig 14. Comparison of red grouper length and subsamples of otolith samples taken from longline (LL) fisheries from 2002-2005. Non-random or biased samples were not included in these length frequency distributions.

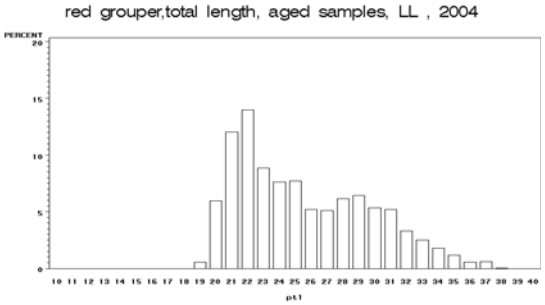


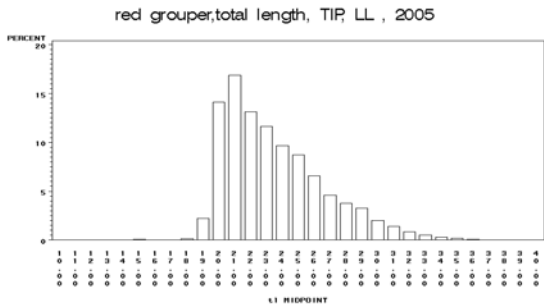












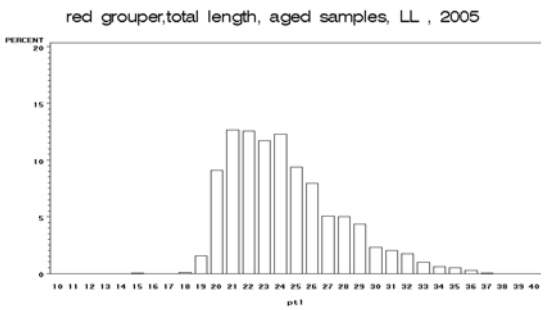
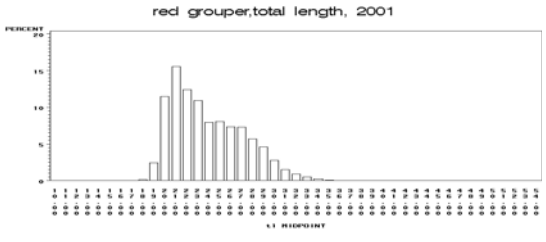
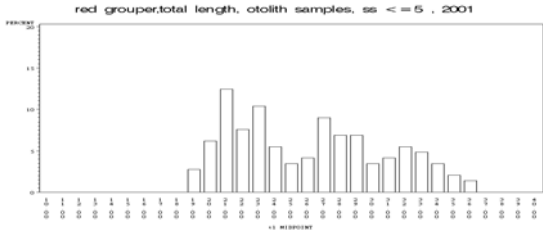
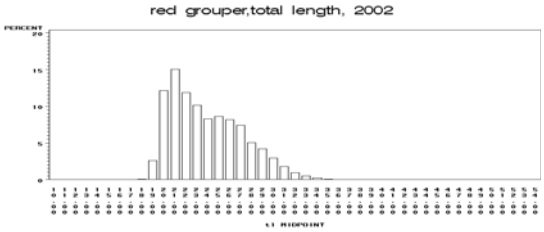
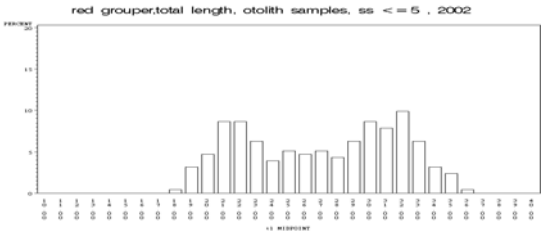


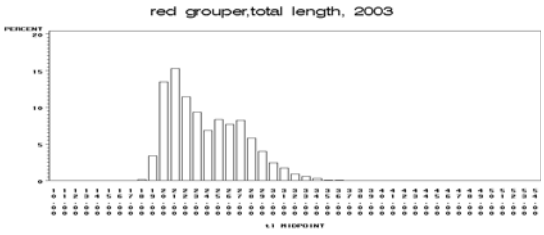
Fig 15. Comparison of length frequency distributions for red grouper length samples and otolith samples that have sample sizes less than 5 (2001-2005).

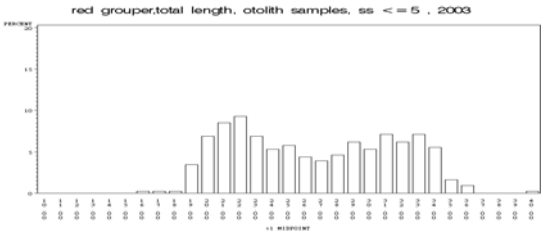


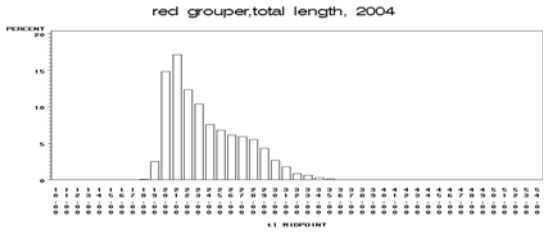


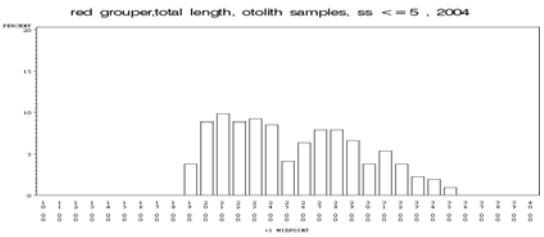


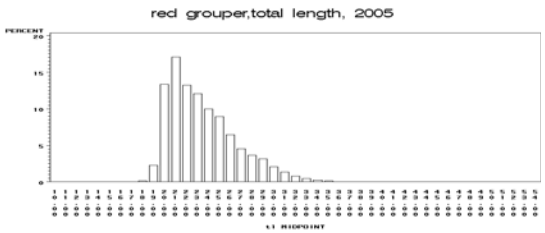












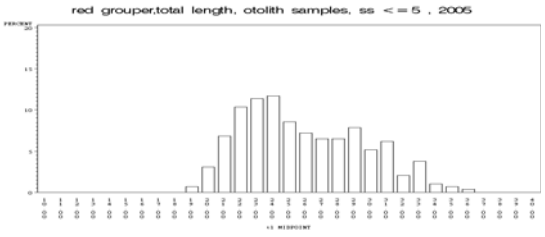
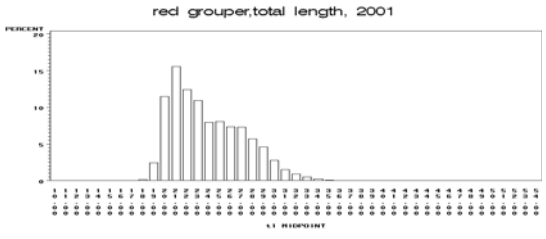
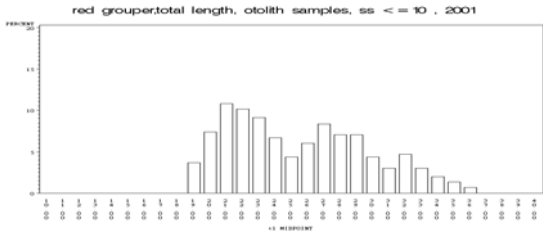
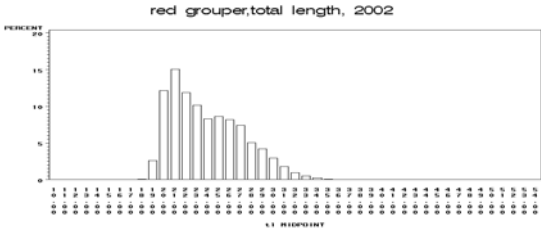
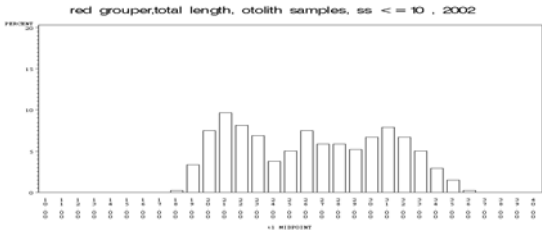


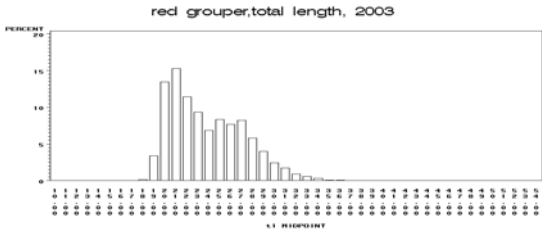
Fig 16. Comparison of length frequency distributions for red grouper length samples and otolith samples that have sample sizes less than 10 (2001-2005)

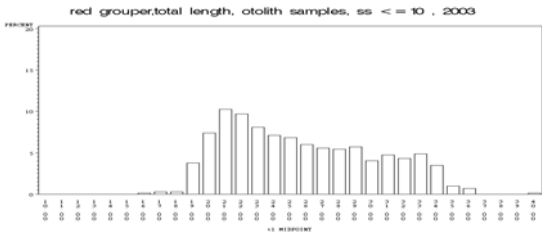


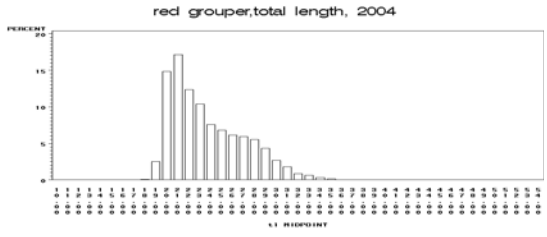


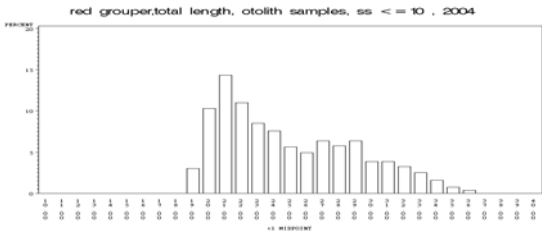


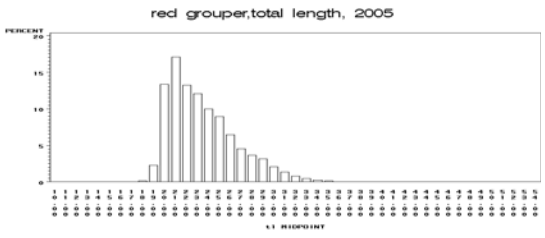












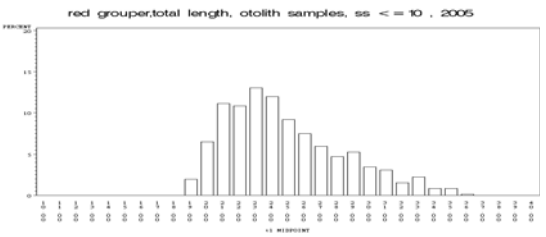
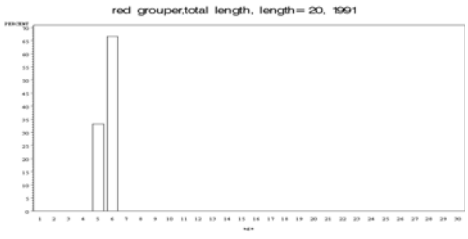
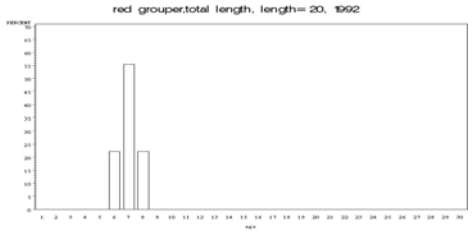
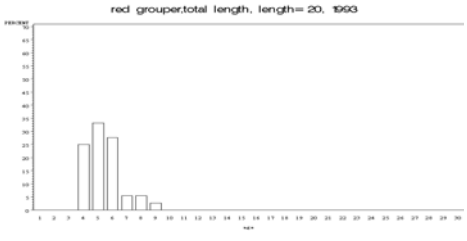
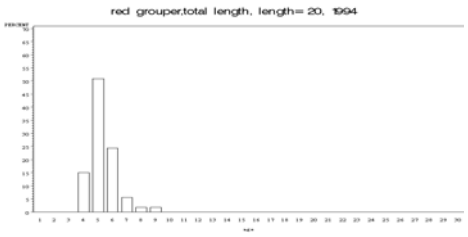


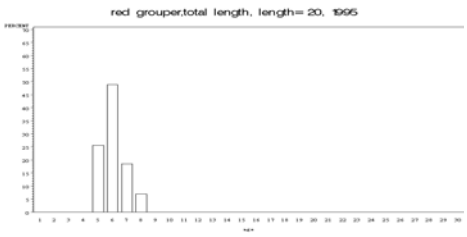
Fig 17.Comparison of age frequency distributions for red grouper otolith samples with length intervals of 20 inches (19.5 <=length < 20.5) collected from 2001 to 2005.

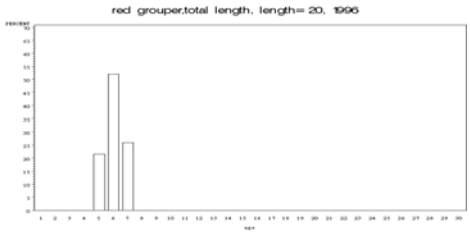


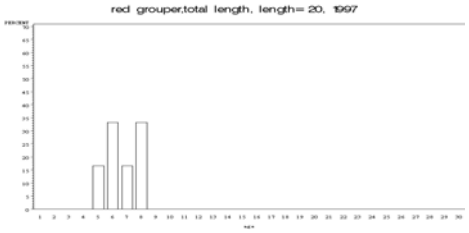












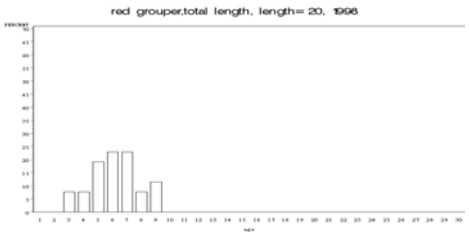
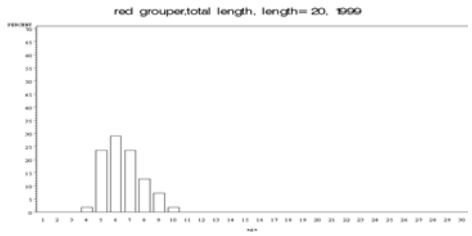
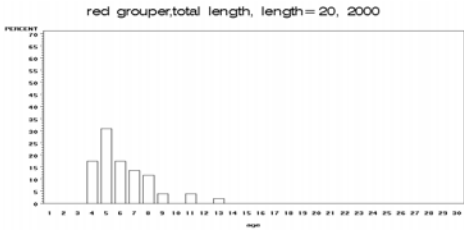
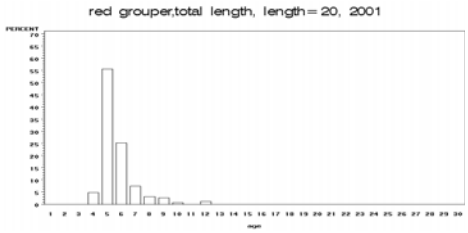
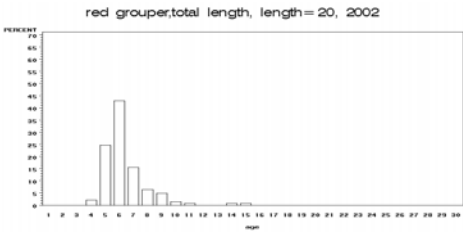


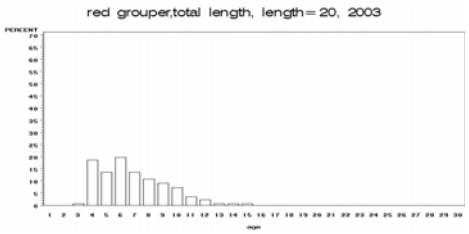
Fig 17 - continued.

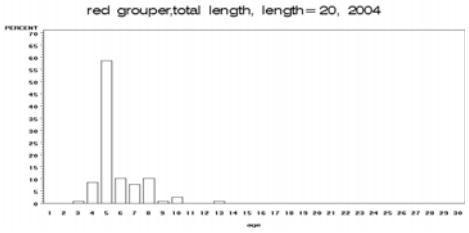


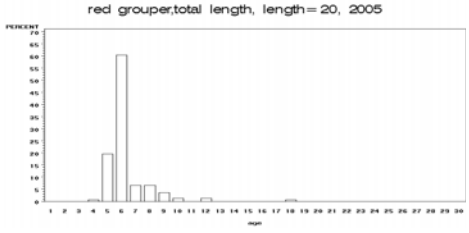












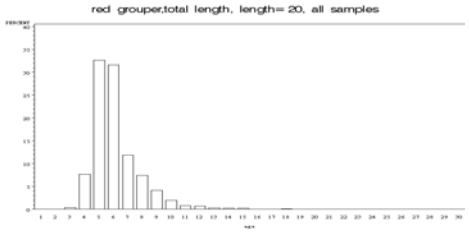
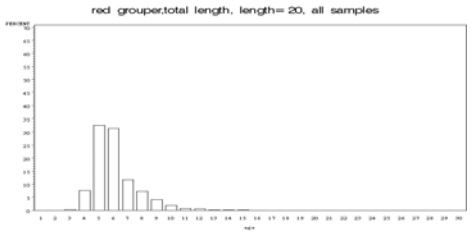
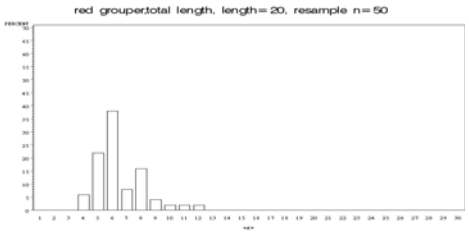


Fig 18. Comparison of age frequency distributions for samples resampled (n=50) from the combined otolith samples with length intervals of 20 inches (19.5 <=length < 20.5).

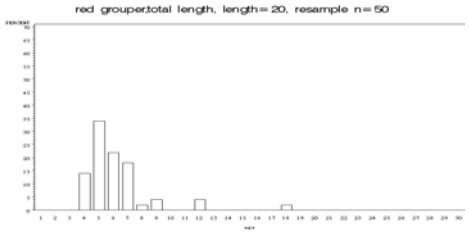
(a)



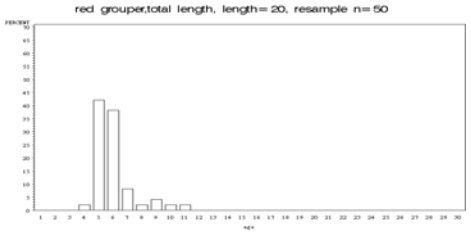
(b)



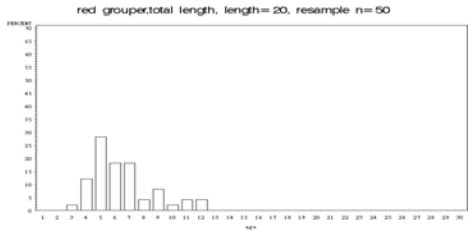
(c)



(d)



(e)



(f)

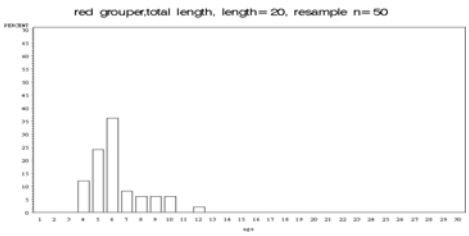
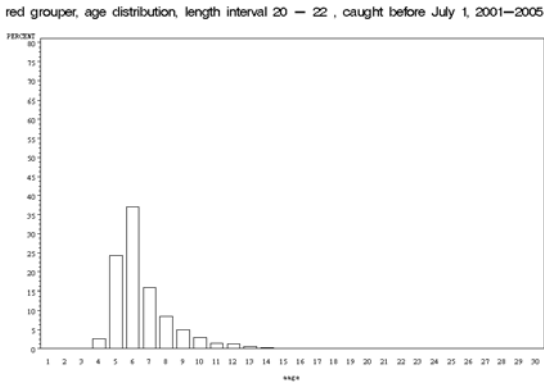
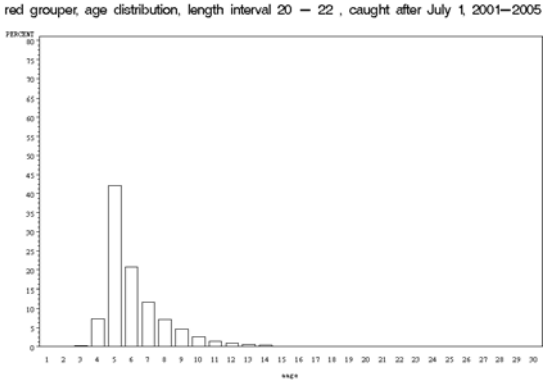
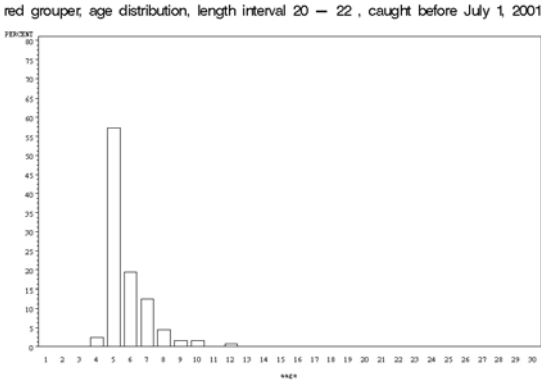
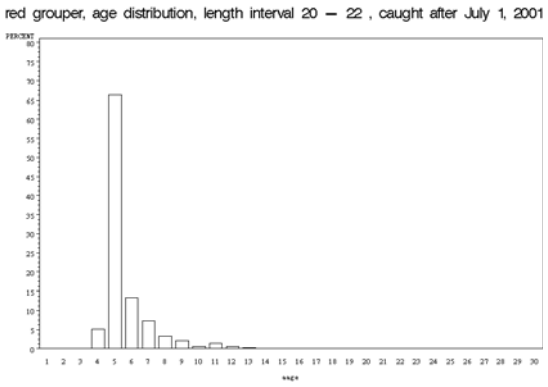


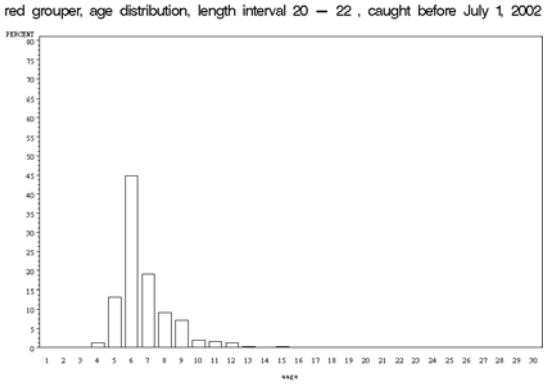
Fig 19. Comparison of age frequency distributions for otolith samples collected before and after July 1 during 2001-2005 (length interval 20-22 inches, i.e. 19.5 inches <=total length <22.5 inches).











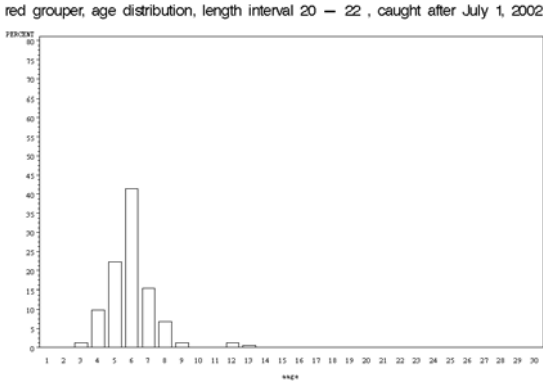
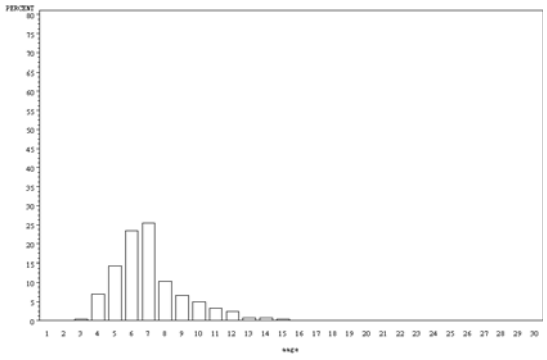
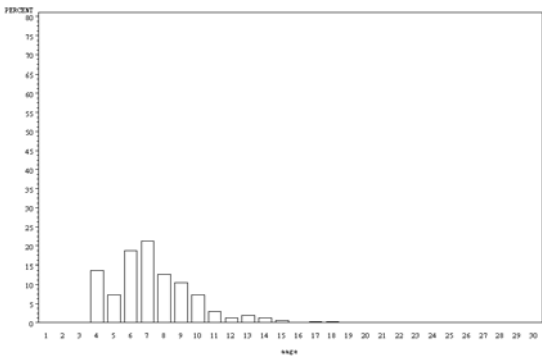


Fig 19. Continued.

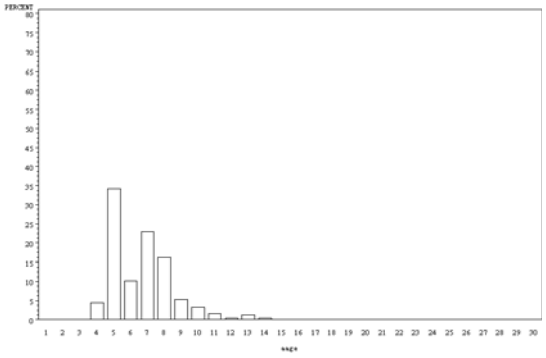
red grouper, age distribution, length interval 20 — 22 , caught before July 1, 2003



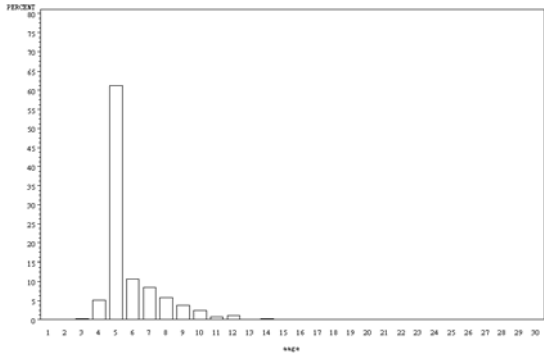
red grouper, age distribution, length interval 20 — 22 , caught after July 1, 2003



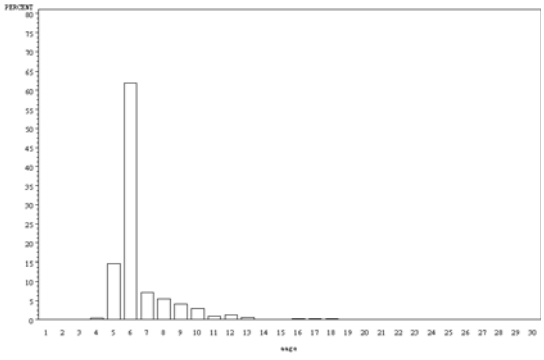
red grouper, age distribution, length interval 20 — 22 , caught before July 1, 2004



red grouper, age distribution, length interval 20 — 22 , caught after July 1, 2004



red grouper, age distribution, length interval 20 — 22 , caught before July 1, 2005



red grouper, age distribution, length interval 20 — 22 , caught after July 1, 2005