Length Frequency Analysis of the Gulf of Mexico Recreational Red Grouper Fishery

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Introduction

The distribution of length and age within a given population is critical information often used in the assessment of that population. Two recreational data collection programs in the Gulf of Mexico assemble length and weight data for a sample of the fish landed by recreational anglers in the region. The Marine Recreational Fisheries Statistics Survey (MRFSS) provides fisheries dependent information across the entire Gulf of Mexico. The Southeast Region Head Boat Survey, facilitated by the NOAA Beaufort Laboratory, collects fisheries dependent biological data to support stock management activities. The Head Boat Survey includes all Gulf States, except for Mississippi. The purpose of this paper is to present length of catch information from these two data sources in order to determine whether significant changes in the size of fish captured has occurred over time and to explore the feasibility of using the length information as a means of estimating age.

Methodology and Discussion

Marine Recreational Fisheries Statistics Survey (MRFSS)

The MRFSS data for red grouper contains length information for the years 1981 through 2005. The majority of the samples were captured using hook and line and a very small portion were captured using spear (Figure 1). The majority of the samples were taken from the state of Florida and a very small portion was taken from the state of Alabama; no samples were taken from Louisiana, Mississippi or Texas (Figure 2). The original length and weight units of the data are millimeters and kilograms respectively. Length units were converted from millimeters to inches using the conversion factor 1 millimeter = 0.0393700787 inches. Weight units were converted from kilograms to pounds using the conversion factor 1 kilogram = 2.20462262 pounds. All length measurements were taken in fork length.

Once the length conversion was complete, the fork length values were non-linearly regressed against the weight values in order to determine and eliminate outlying values from the data before analysis (Figure 3). Records where weights and/or lengths were said to be equal to zero were removed (n = 442). With the remaining data, an initial

fit of fork length to weight was made (Figure 4). The residuals from this linear fit were calculated (Figure 5) and points outside of the 99% confidence limit were removed. The final fit (Figure 6) provided the following conversion from weight in pounds to fork length in inches:

$$W = 0.084*FL^{3.035}$$

The resulting dataset was used in the subsequent analysis of length frequency across strata.

Length frequency analysis of the resulting MRFSS data was carried out for the strata year, wave, mode and fishing area. Wave corresponds to the bimonthly sampling period used by MRFSS: January/February, March/April, May/June, July/August, September/October, November/December. Mode refers to the vessel that was used to fish: charter boat, head boat, private boat, or from shore. Head boats were only sampled by MRFSS from 1981 through 1985; the NMFS Head Boat Survey took over this mode starting in 1986. Length frequency analysis for the NMFS Head Boat Survey is provided in the later portion of this paper. Summary statistics are presented for the analysis of length data by year, wave, mode and fishing area, as well as the interaction of year with wave, mode, and fishing area. These results are presented in tabular form in Tables 1 through 11. Length frequency histograms were generated for each strata and are presented after Figure 6. Histograms were not generated for the interactions of year with each of the strata due to poor sample sizes for some years within each strata.

NMFS Head Boat Survey

The head boat data for red grouper contains length information for the years 1986 through 2005. The majority of the samples were taken from the state of Florida (west coast) and some of the samples were from the state of Alabama; a few samples were taken in Texas prior to the inception of their own state organized department of parks survey (Figure 7). No samples were taken from Mississippi or Louisiana. The original length and weight units of the data are millimeters and grams respectively. Length units were converted from millimeters to inches using the conversion factor 1 millimeter = 0.0393700787 inches. Weight units were converted from grams to pounds using the conversion factor 1 gram = 0.00220462262 pounds. In addition, some of the records

contain measured length in total length while others record the measured length in fork length. Some of the records contained measured lengths in both total and fork length. In order to make all length records comparable, those records that contained both total and fork length were isolated and regressed in order to determine the quantitative relationship between the two units of measure and convert all of the length data to fork length. The raw data that contained both measurements for total and fork length were regressed and a linear relationship was fit (Figure 8). The residuals of the linear fit were calculated (Figure 9) and points outside of the 99% confidence limit were removed. The final fit (Figure 10) provided the following conversion from total length in inches to fork length in inches:

$$FL = 0.3377252 + 0.9460861*TL$$

This conversion was then applied to estimate fork length for those records that contained information on total length only.

Once the length conversion was complete, the fork length values were non-linearly regressed against the weight values in order to determine and eliminate outlying values from the data before analysis (Figure 11). Records where weights and/or lengths were said to be equal to zero were removed (n = 118). In addition, one record that recorded a red grouper of 208.92 inches with a weight of 5.47 pounds was removed based on the implausibility of these values. With the remaining data, an initial fit of fork length to weight was made (Figure 12). The residuals from this linear fit were calculated (Figure 13) and points outside of the 99% confidence limit were removed. The final fit (Figure 14) provided the following conversion from weight in pounds to fork length in inches:

$$W = 0.083*FL^{3.143}$$

The resulting dataset was used in the subsequent analysis of length frequency across strata.

The data collected by the NMFS Head Boat program is assigned to different areas depending on where the sample is reportedly caught. The following lists the area number and description of area location:

5

Area Number	Area Description
12	Florida Keys, Atlantic based vessels
17	Dry Tortugas, Keys based vessels
18	Dry Tortugas, Gulf based vessels
20	SW FL: Naples to Crystal River (half and three quarter day trips)
21	SW FL: Naples to Crystal River (full day trips)
22	Florida Middle Grounds (FL west and Panhandle)
23	NW Florida and Alabama (Panama City, FL to Orange Beach, AL)
24	Louisiana
25	NE Texas (Sabine to Freeport)
26	Central Texas (Port Aransas)
27	South Texas (Port Isabel and Brownsville)

The inclusion of data from data from areas 12 and 17 in assessments of fisheries in the Gulf of Mexico is often debated due to the fact that landings in each of these areas also come from Atlantic waters. Consequently, the length frequency analysis of the head boat length data has been done using two different data sets: one including the data from areas 12 and 17, and the other excluding the data from areas 12 and 17. Average length of red grouper sampled was analyzed with each of these data sets according to the strata year and season. The data overall was also analyzed according to area. It was not possible to analyze the interactions of year within the strata season or area due to the fact that sample size was not large enough. Tabulated summary results of these analyses are presented in tables 12 through 16, and length frequency histograms are presented for the analyses at the end of this report.

MRFSS TABLES

Year	N	Mean	Variance	Standard Deviation	CV
1981	55	17.54	25.40	5.04	28.74
1982	99	17.46	34.76	5.90	33.77
1983	108	18.80	41.10	6.41	34.11
1984	101	17.74	16.91	4.11	23.18
1985	41	19.61	27.18	5.21	26.59
1986	71	16.28	8.15	2.86	17.53
1987	139	16.28	17.08	4.13	25.38
1988	236	17.23	15.11	3.89	22.56
1989	214	16.95	9.83	3.14	18.50
1990	49	21.43	6.45	2.54	11.85
1991	106	21.21	5.29	2.30	10.85
1992	341	21.54	5.80	2.41	11.18
1993	140	20.94	4.54	2.13	10.18
1994	153	21.23	5.55	2.35	11.09
1995	190	22.17	7.26	2.69	12.15
1996	76	22.17	6.80	2.61	11.77
1997	79	21.71	5.11	2.26	10.41
1998	210	21.36	7.93	2.82	13.19
1999	391	21.83	6.98	2.64	12.10
2000	504	21.71	9.55	3.09	14.23
2001	461	21.57	6.63	2.57	11.94
2002	611	22.15	7.42	2.72	12.30
2003	749	21.19	7.13	2.67	12.60
2004	1,569	21.50	6.13	2.48	11.52
2005	1,208	21.71	5.95	2.44	11.23

Table 1: MRFSS length frequency summary statistics for each year.

Wave	N	Mean	Variance	Standard Deviation	CV
1	638	21.04	13.95	3.74	17.75
2	959	21.31	11.23	3.35	15.72
3	2,059	21.26	10.62	3.26	15.33
4	1,677	20.87	11.31	3.36	16.11
5	1,710	20.83	9.22	3.04	14.57
6	858	20.83	8.92	2.99	14.34

Table 2: MRFSS length frequency summary statistics for each wave (bimonthly sampling period).

Mode	N	Mean	Variance	Standard Deviation	CV
charterboat	5,267	21.45	7.41	2.72	12.69
headboat	137	19.43	30.99	5.57	28.65
private boat	2,453	20.29	14.73	3.84	18.92
shore	44	16.45	30.05	5.48	33.32

Table 3: MRFSS length frequency summary statistics for each mode of fishing.

Year	N	Mean	Variance	Standard Deviation	CV
1981	11	21.21	23.45	4.84	22.84
1982	1	14.96			.
1983	10	25.43	17.77	4.22	16.58
1984	25	20.31	13.00	3.61	17.75
1986	38	16.50	7.36	2.71	16.44
1987	27	18.02	24.62	4.96	27.53
1988	48	18.67	13.42	3.66	19.62
1989	59	17.62	7.91	2.81	15.97
1990	13	21.10	3.21	1.79	8.49
1991	13	19.31	1.80	1.34	6.96
1992	114	21.69	7.34	2.71	12.49
1993	21	20.70	2.56	1.60	7.73
1994	58	21.33	4.98	2.23	10.46
1995	73	22.63	10.17	3.19	14.09
1996	31	22.19	8.81	2.97	13.38
1997	49	21.94	4.21	2.05	9.35
1998	130	21.10	7.84	2.80	13.27
1999	255	21.81	6.35	2.52	11.56
2000	372	21.58	8.67	2.94	13.64
2001	351	21.45	6.34	2.52	11.74
2002	487	22.06	7.57	2.75	12.47
2003	658	21.20	7.18	2.68	12.64
2004	1,317	21.50	5.89	2.43	11.29
2005	1,106	21.67	5.79	2.41	11.10

Table 4: MRFSS length frequency summary statistics for charter boat by year.

Year	N	Mean	Variance	Standard Deviation	CV
1981	16	16.69	17.46	4.18	25.04
1982	7	24.66	39.90	6.32	25.61
1983	37	21.45	43.48	6.59	30.73
1984	48	17.05	15.37	3.92	22.99
1985	29	21.04	21.96	4.69	22.27

Table 5: MRFSS length frequency summary statistics for head boat by year.

Year	N	Mean	Variance	Standard Deviation	CV
1981	16	18.39	34.59	5.88	31.97
1982	89	17.12	29.73	5.45	31.84
1983	59	16.21	25.52	5.05	31.16
1984	26	17.03	14.72	3.84	22.52
1985	12	16.14	24.39	4.94	30.60
1986	33	16.03	9.20	3.03	18.92
1987	111	15.91	14.43	3.80	23.88
1988	184	16.94	13.50	3.67	21.69
1989	155	16.69	10.38	3.22	19.30
1990	36	21.55	7.69	2.77	12.87
1991	91	21.42	5.21	2.28	10.66
1992	214	21.51	5.03	2.24	10.43
1993	117	20.97	4.91	2.22	10.57
1994	93	21.31	4.72	2.17	10.20
1995	117	21.89	5.31	2.30	10.53
1996	45	22.15	5.59	2.36	10.67
1997	29	21.67	3.40	1.84	8.51
1998	79	21.76	7.98	2.82	12.98
1999	136	21.89	8.20	2.86	13.08
2000	132	22.06	11.93	3.45	15.66
2001	110	21.94	7.41	2.72	12.41
2002	124	22.49	6.73	2.59	11.53
2003	91	21.14	6.80	2.61	12.33
2004	252	21.46	7.42	2.72	12.69
2005	102	22.22	7.48	2.74	12.31

Table 6: MRFSS length frequency summary statistics for private boat by year.

Year	N	Mean	Variance	Standard Deviation	CV
1981	12	14.17	4.44	2.11	14.87
1982	2	8.27	1.94	1.39	16.84
1983	2	12.60	19.84	4.45	35.36
1984	2	11.22	1.94	1.39	12.41
1987	1	10.63			
1988	4	13.28	90.80	9.53	71.77
1991	2	23.86	0.00	0.00	0.00
1992	13	20.79	5.08	2.25	10.84
1993	2	21.65	7.75	2.78	12.86
1994	2	14.82	42.07	6.49	43.76
1997	1	11.77			
1998	1	23.23			

Table 7: MRFSS length frequency summary statistics for shore mode by year.

Year	N	Mean	Variance	Standard	CV
1981	3	9.16	6.26	2.50	27.32
1984	2	11.22	1.94	1.39	12.41
1987	1	16.14			
1988	4	9.25	2.74	1.65	17.89
1989	1	11.65			
1991	1	23.86			
1992	2	22.34	0.04	0.19	0.87
1993	23	19.75	4.14	2.04	10.30
1995	1	22.83			
1997	2	22.26	3.69	1.92	8.63
1998	3	26.71	1.33	1.15	4.32
2000	1	29.92			
2001	3	21.01	2.16	1.47	6.99
2003	1	23.62			

Table 8: MRFSS length frequency summary statistics for fishing area inshore by year.

Year	N	Mean	Variance	Standard Deviation	CV
1981	20	14.74	7.93	2.82	19.10
1982	43	14.75	13.97	3.74	25.35
1983	24	15.28	13.54	3.68	24.08
1984	30	15.87	8.91	2.99	18.82
1985	5	17.47	68.51	8.28	47.37
1986	16	15.54	10.58	3.25	20.94
1987	32	15.46	14.64	3.83	24.75
1988	18	18.25	17.56	4.19	22.96
1989	7	19.16	0.51	0.72	3.74
1990	6	19.06	0.68	0.82	4.32
1991	33	21.11	4.62	2.15	10.18
1992	43	21.61	8.09	2.84	13.16
1993	13	20.73	2.62	1.62	7.81
1994	19	19.92	8.46	2.91	14.60
1995	15	21.42	6.55	2.56	11.95
1996	10	21.76	2.97	1.72	7.92
1997	14	20.51	10.37	3.22	15.70
1998	32	20.69	7.25	2.69	13.01
1999	41	20.84	6.96	2.64	12.66
2000	43	20.99	4.45	2.11	10.05
2001	16	20.58	2.64	1.63	7.90
2002	54	21.89	4.38	2.09	9.57
2003	50	20.59	4.98	2.23	10.83
2004	98	20.52	1.60	1.26	6.16
2005	120	21.46	4.58	2.14	9.97

Table 9: MRFSS length frequency summary statistics for fishing area less than or equal to 10 miles from shore.

Year	N	Mean	Variance	Standard Deviation	CV
1981	32	20.07	20.54	4.53	22.58
1982	56	19.54	41.11	6.41	32.82
1983	84	19.80	44.64	6.68	33.75
1984	69	18.74	17.22	4.15	22.14
1985	36	19.90	22.49	4.74	23.83
1986	55	16.50	7.41	2.72	16.50
1987	106	16.53	17.85	4.23	25.56
1988	214	17.29	13.94	3.73	21.59
1989	206	16.90	9.89	3.15	18.61
1990	43	21.76	6.38	2.53	11.61
1991	71	21.27	5.49	2.34	11.02
1992	296	21.53	5.53	2.35	10.92
1993	104	21.23	4.53	2.13	10.03
1994	134	21.41	4.91	2.22	10.35
1995	173	22.28	6.96	2.64	11.84
1996	66	22.23	7.41	2.72	12.24
1997	63	21.96	3.80	1.95	8.87
1998	175	21.39	7.65	2.77	12.93
1999	348	21.97	6.76	2.60	11.83
2000	459	21.76	9.85	3.14	14.42
2001	441	21.60	6.76	2.60	12.04
2002	528	22.27	7.78	2.79	12.52
2003	642	21.34	7.30	2.70	12.66
2004	1363	21.64	6.50	2.55	11.78
2005	1010	21.83	5.77	2.40	11.00

Table 10: MRFSS length frequency summary statistics for fishing area greater than 10 miles from shore.

Year	N	Mean	Variance	Standard	CV
1991	1	17.24			
1995	1	13.62			
1999	2	17.68	15.63	3.95	22.36
2000	1	17.87			
2001	1	25.20			
2002	29	20.42	3.42	1.85	9.05
2003	56	19.93	5.05	2.25	11.28
2004	108	20.57	3.66	1.91	9.30
2005	78	20.56	8.99	3.00	14.58

Table 11: MRFSS length frequency summary statistics for fishing area greater than three miles from shore.

HEAD BOAT TABLES

Year	N	Mean	Variance	Standard Deviation	CV
1986	360	16.74	19.96	4.47	26.68
1987	543	17.27	14.22	3.77	21.83
1988	347	17.68	16.56	4.07	23.01
1989	669	16.42	18.93	4.35	26.50
1990	243	21.45	18.93	4.35	20.29
1991	99	23.12	15.10	3.89	16.81
1992	54	22.33	11.56	3.40	15.22
1993	31	22.23	21.61	4.65	20.91
1994	52	20.91	8.37	2.89	13.84
1995	57	21.83	7.44	2.73	12.49
1996	71	21.31	6.93	2.63	12.36
1997	47	21.31	7.57	2.75	12.92
1998	40	20.20	5.09	2.26	11.17
1999	106	21.79	7.35	2.71	12.44
2000	69	21.00	5.57	2.36	11.24
2001	52	21.10	5.74	2.40	11.35
2002	129	20.26	3.35	1.83	9.03
2003	217	20.27	3.76	1.94	9.57
2004	172	20.23	2.25	1.50	7.41
2005	72	21.22	2.30	1.52	7.15

Table 12: Head boat summary statistics by year NOT INCLUDING areas 12 and 17.

Season	N	Mean	Variance	Standard Deviation	CV
Fall	762	18.44	16.63	4.08	22.11
Spring	996	18.88	19.43	4.41	23.34
Summer	1,182	19.01	17.03	4.13	21.70
Winter	489	18.61	19.78	4.45	23.90

Table 13: Head boat summary statistics by season NOT INCLUDING areas 12 and 17.

Year	N	Mean	Variance	Standard Deviation	CV
1986	630	17.29	17.27	4.16	24.03
1987	760	17.74	14.35	3.79	21.35
1988	469	17.87	15.54	3.94	22.07
1989	850	17.18	19.10	4.37	25.43
1990	348	21.24	15.29	3.91	18.41
1991	121	22.64	14.08	3.75	16.57
1992	90	22.18	10.19	3.19	14.39
1993	107	21.49	11.56	3.40	15.82
1994	128	21.20	6.49	2.55	12.01
1995	147	21.72	5.61	2.37	10.91
1996	222	21.53	6.10	2.47	11.47
1997	198	21.68	6.87	2.62	12.09
1998	221	21.05	6.20	2.49	11.83
1999	240	21.52	6.14	2.48	11.52
2000	185	21.08	4.39	2.10	9.94
2001	132	21.50	6.50	2.55	11.86
2002	255	20.69	4.26	2.07	9.98
2003	286	20.41	3.59	1.90	9.29
2004	218	20.46	3.07	1.75	8.57
2005	107	21.28	3.26	1.81	8.49

Table 14: Head boat summary statistics by year INCLUDING areas 12 and 17.

Season	N	Mean	Variance	Standard Deviation	CV
Fall	1,338	19.34	14.60	3.82	19.76
Spring	1,539	19.53	16.49	4.06	20.80
Summer	1,485	19.28	14.89	3.86	20.02
Winter	1,351	19.70	15.05	3.88	19.70

Table 15: Head boat summary statistics by season INCLUDING areas 12 and 17.

Area	N	Mean	Variance	Standard Deviation	CV
12	1,810	20.46	7.44	2.73	13.33
17	474	20.44	17.51	4.18	20.47
18	31	24.02	18.55	4.31	17.93
21	2,563	17.67	14.23	3.77	21.34
22	152	21.70	20.30	4.51	20.76
23	667	22.15	13.10	3.62	16.34
25	3	17.35	27.41	5.24	30.18
26	14	20.34	12.56	3.54	17.42

Table 16: Head boat summary statistics for each area.

MRFSS CHARTS

Gears Represented In MRFSS Length Samples

☐ None Specified ☐ Hook and Line ☐ Cast Net ☐ Trawl ☐ Spear ☐ Hand
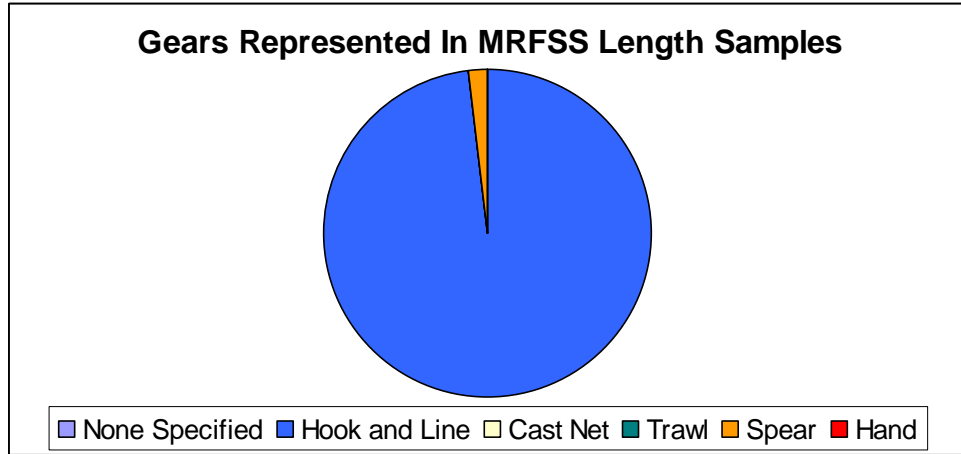
Figure 1: Gears sampled by the MRFSS length sampling program.

States Represented in MRFSS Length Samples

☐ Alabama ☐ Florida (west coast) ☐ Louisiana ☐ Mississippi ☐ Texas
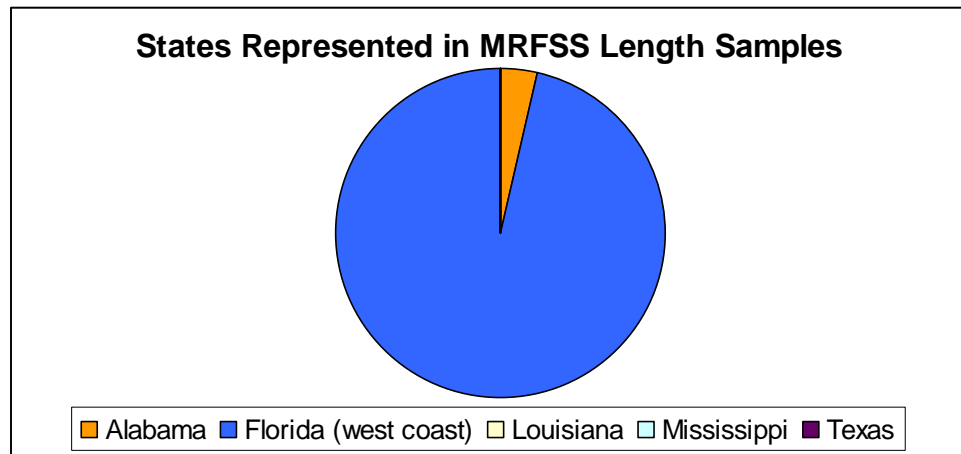
Figure 2: States sampled by the MRFSS length sampling program.
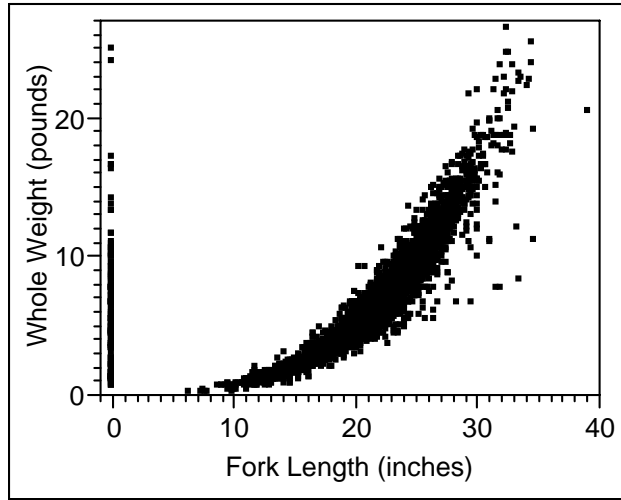
Figure 3: MRFSS Gulf of Mexico raw red grouper length and weight data (n = 8,422).
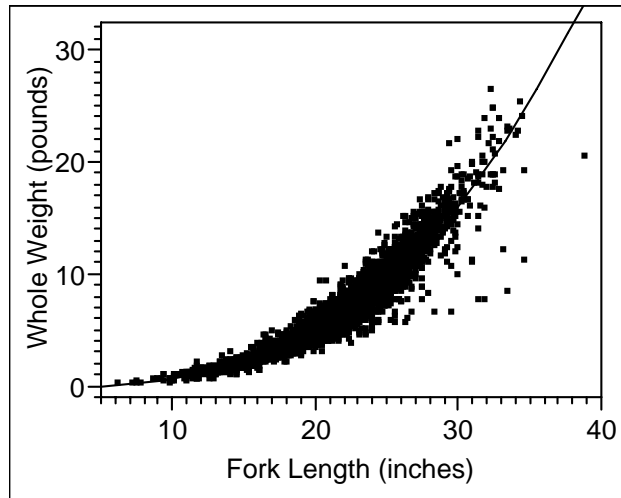
Parameter	Estimate	Low	High
a	0.0855640696	0.08434	0.08679
b	2.9408658263	2.88327	2.99846

Figure 4: Initial fit to MRFSS red grouper data without zero weight and zero age data (n = 7,980).

Quantile

100.0%	maximum	6.58
99.5%		3.16
97.5%		1.84
90.0%		0.90
75.0%	quartile	0.35
50.0%	median	-0.06
25.0%	quartile	-0.43
10.0%		-0.78
2.5%		-1.47
0.5%		-3.16
0.0%	minimum	-14.04

Moment

Mean	-0.014529
Std Dev	0.8958657
Std Err Mean	0.0100286
upper 95% Mean	0.0051297
lower 95% Mean	-0.034188
N	7980
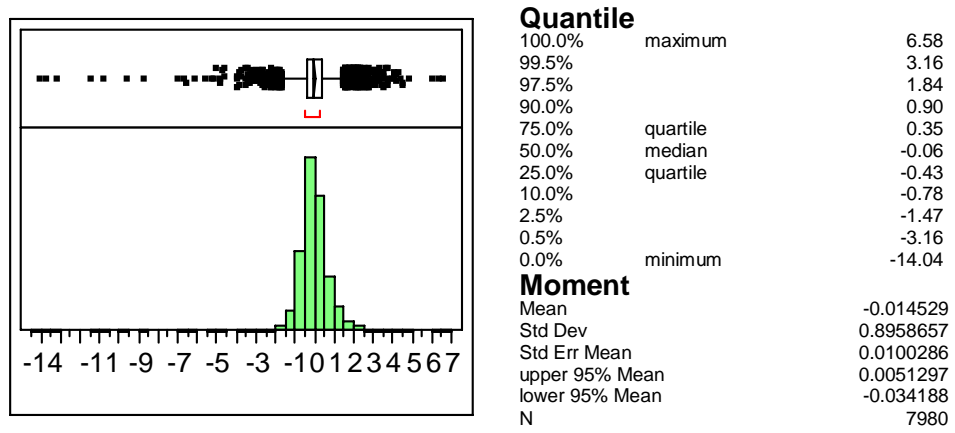
Figure 5: MRFSS length weight fit residuals for Gulf of Mexico red grouper.

Parameter	Estimate	Low	High
a	0.0838559413	0.08289	0.08482
b	3.0346421422	2.98513	3.08416
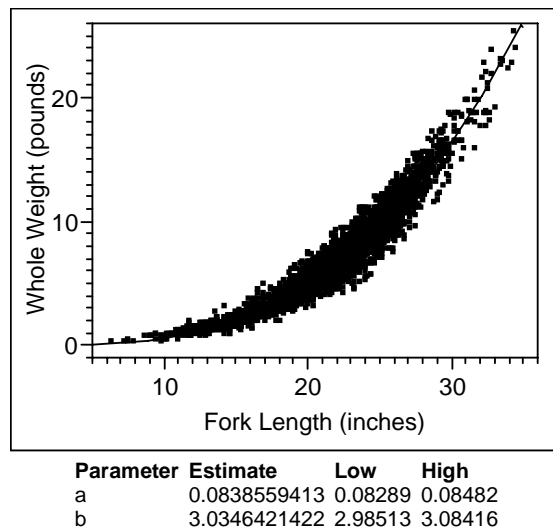
Figure 6: MRFSS final length width fit and parameter estimation with residuals removed (n = 7901).

MRFSS Length Frequency Distributions

1981
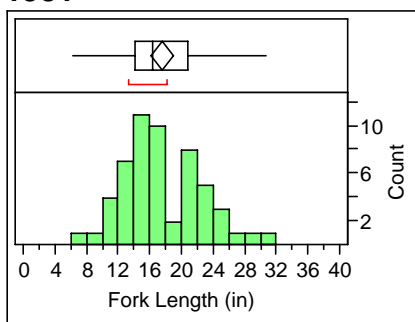
Mean	17.537581
Std Dev	5.0400354
Std Err Mean	0.6795982
upper 95% Mean	18.900093
lower 95% Mean	16.175068
N	55

1984
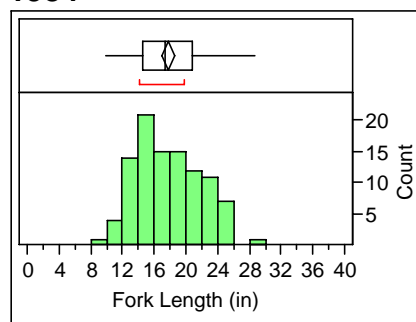
Mean	17.739144
Std Dev	4.1121
Std Err Mean	0.4091692
upper 95% Mean	18.550924
lower 95% Mean	16.927364
N	101

1982
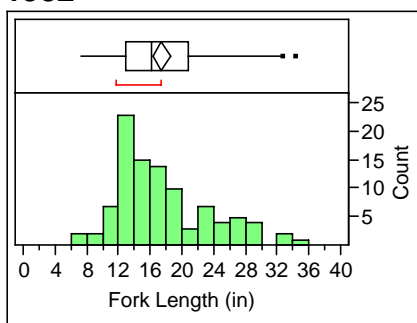
Mean	17.456852
Std Dev	5.8955696
Std Err Mean	0.592527
upper 95% Mean	18.632703
lower 95% Mean	16.281001
N	99

1985
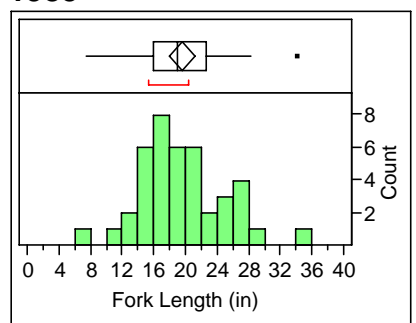
Mean	19.605339
Std Dev	5.2130391
Std Err Mean	0.8141399
upper 95% Mean	21.250777
lower 95% Mean	17.959901
N	41

1983
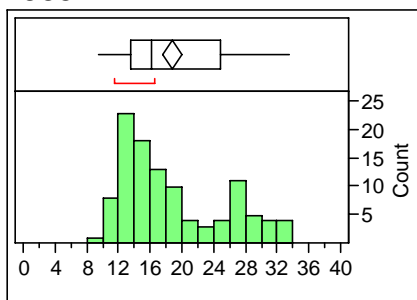
Mean	18.795567
Std Dev	6.4109304
Std Err Mean	0.6168921
upper 95% Mean	20.018484
lower 95% Mean	17.572651
N	108

1986
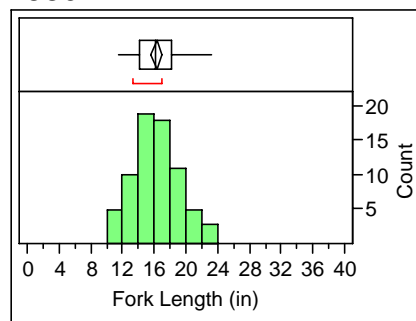
Mean	16.284241
Std Dev	2.8551034
Std Err Mean	0.3388384
upper 95% Mean	16.960033
lower 95% Mean	15.608449
N	71

1987
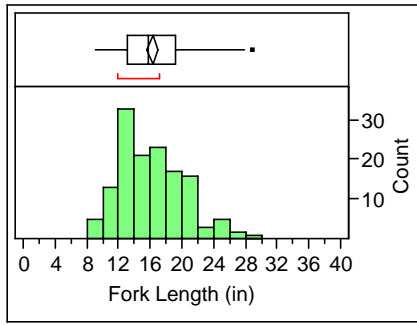
Mean	16.283068
Std Dev	4.1324311
Std Err Mean	0.3505082
upper 95% Mean	16.976129
lower 95% Mean	15.590007
N	139

1988

Mean	17.227913
Std Dev	3.8869723
Std Err Mean	0.2530203
upper 95% Mean	17.726391
lower 95% Mean	16.729435
N	236

1989

Mean	16.947347
Std Dev	3.135466
Std Err Mean	0.214336
upper 95% Mean	17.369839
lower 95% Mean	16.524856
N	214

1990

Mean	21.430982
Std Dev	2.5404069
Std Err Mean	0.3629153
upper 95% Mean	22.160672
lower 95% Mean	20.701292
N	49

1991

Mean	21.20673
Std Dev	2.3008148
Std Err Mean	0.2234749
upper 95% Mean	21.649839
lower 95% Mean	20.763621
N	106

1992
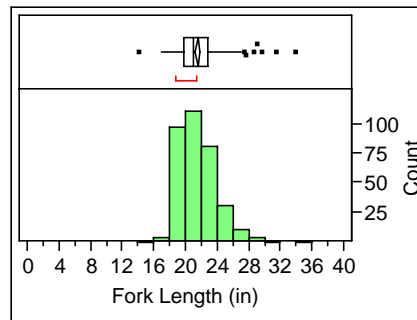
Mean	21.544439
Std Dev	2.4084274
Std Err Mean	0.1304237
upper 95% Mean	21.800977
lower 95% Mean	21.2879
N	341

1993
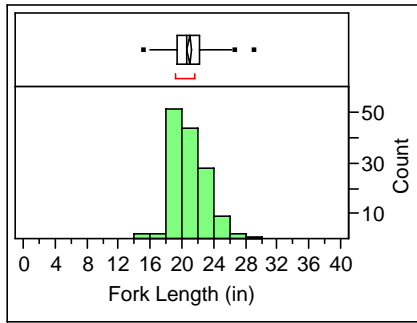
Mean	20.939539
Std Dev	2.1308578
Std Err Mean	0.1800903
upper 95% Mean	21.295609
lower 95% Mean	20.583468
N	140

1994

Mean	21.228707
Std Dev	2.354944
Std Err Mean	0.1903859
upper 95% Mean	21.604851
lower 95% Mean	20.852562
N	153

1995

Mean	22.172814
Std Dev	2.6944225
Std Err Mean	0.195474
upper 95% Mean	22.558405
lower 95% Mean	21.787223
N	190

1996

Mean	22.167944
Std Dev	2.6082875
Std Err Mean	0.2991911
upper 95% Mean	22.763964
lower 95% Mean	21.571925
N	76

1997

Mean	21.713346
Std Dev	2.2605302
Std Err Mean	0.2543295
upper 95% Mean	22.219677
lower 95% Mean	21.207015
N	79

1998
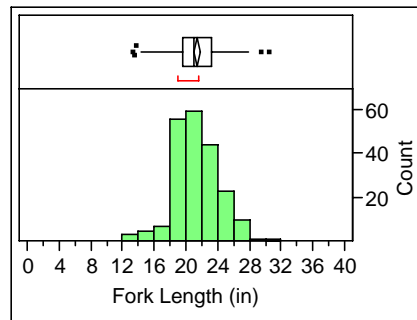
Mean	21.356393
Std Dev	2.8165327
Std Err Mean	0.1943592
upper 95% Mean	21.739549
lower 95% Mean	20.973237
N	210

1999
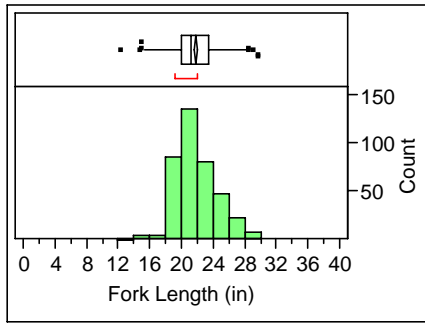
Mean	21.833377
Std Dev	2.6414645
Std Err Mean	0.1335846
upper 95% Mean	22.096013
lower 95% Mean	21.570741
N	391

2002
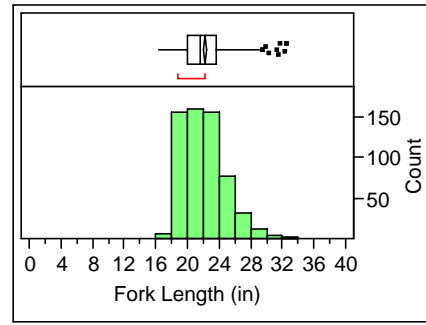
Mean	22.147377
Std Dev	2.7235443
Std Err Mean	0.1101828
upper 95% Mean	22.36376
lower 95% Mean	21.930993
N	611

2000
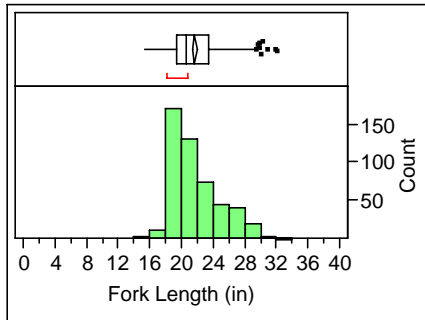
Mean	21.706896
Std Dev	3.0899038
Std Err Mean	0.1376353
upper 95% Mean	21.977307
lower 95% Mean	21.436485
N	504

2003
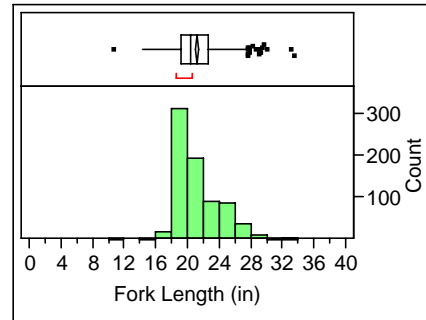
Mean	21.190248
Std Dev	2.6694781
Std Err Mean	0.0975406
upper 95% Mean	21.381734
lower 95% Mean	20.998762
N	749

2001
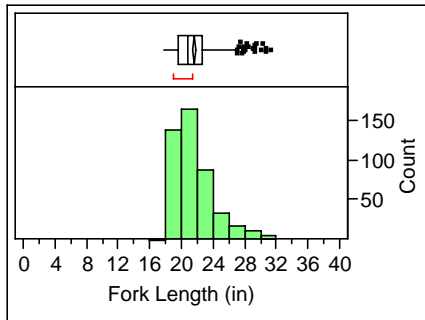
Mean	21.566348
Std Dev	2.5742836
Std Err Mean	0.1198963
upper 95% Mean	21.801961
lower 95% Mean	21.330736
N	461

2004
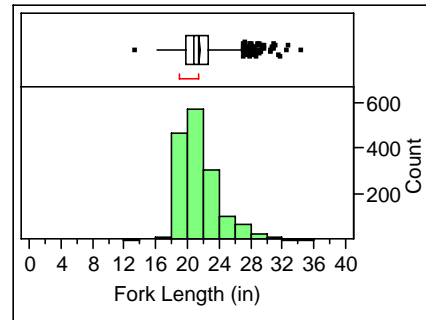
Mean	21.497217
Std Dev	2.4767232
Std Err Mean	0.0625268
upper 95% Mean	21.619862
lower 95% Mean	21.374572
N	1569

2005
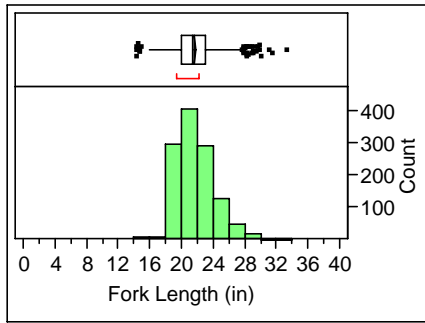
Mean	21.712761
Std Dev	2.4388338
Std Err Mean	0.0701696
upper 95% Mean	21.850429
lower 95% Mean	21.575094
N	1208

Wave Three: May and June
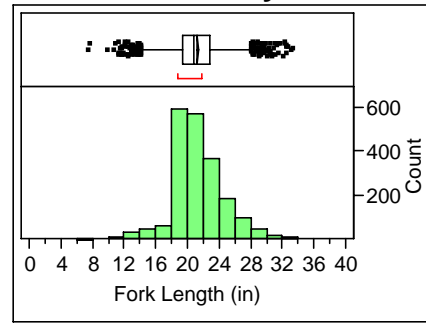
Mean	21.255923
Std Dev	3.2589254
Std Err Mean	0.0718201
upper 95% Mean	21.39677
lower 95% Mean	21.115075
N	2059

Wave One: January and February
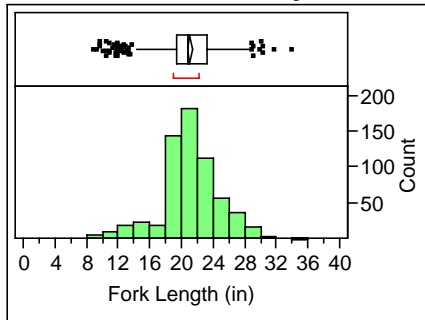
Mean	21.04306
Std Dev	3.7354301
Std Err Mean	0.1478871
upper 95% Mean	21.333465
lower 95% Mean	20.752655
N	638

Wave Four: July and August
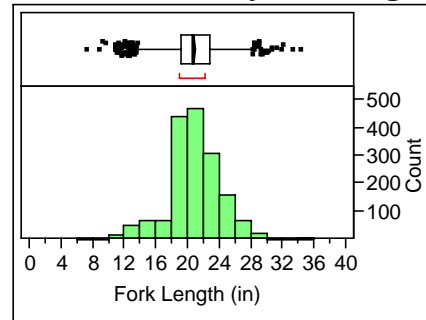
Mean	20.871541
Std Dev	3.3634283
Std Err Mean	0.0821326
upper 95% Mean	21.032635
lower 95% Mean	20.710448
N	1677

Wave Two: March and April
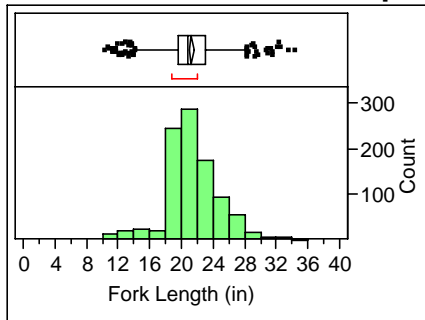
Mean	21.311529
Std Dev	3.3507739
Std Err Mean	0.1082021
upper 95% Mean	21.523869
lower 95% Mean	21.099188
N	959

Wave Five: Sept. and October
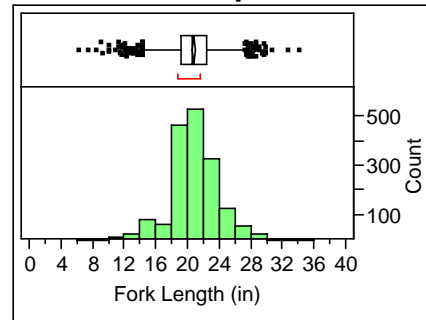
Mean	20.83407
Std Dev	3.0356628
Std Err Mean	0.07341
upper 95% Mean	20.978053
lower 95% Mean	20.690087
N	1710

Wave Six: Nov. and December
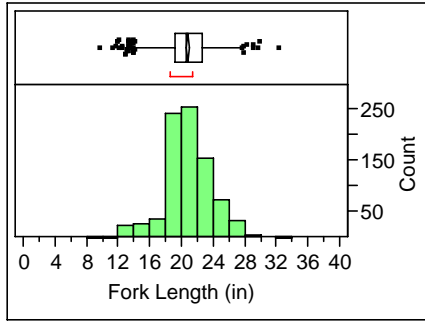
Mean	20.834664
Std Dev	2.9872184
Std Err Mean	0.101982
upper 95% Mean	21.034828
lower 95% Mean	20.6345
N	858

Private Boat Mode
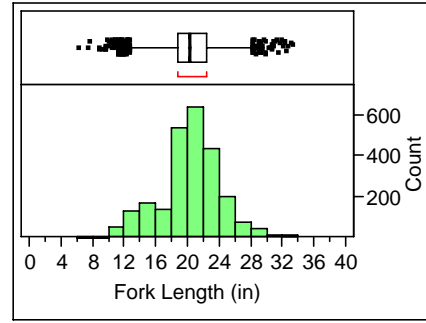
Mean	20.289249
Std Dev	3.8382183
Std Err Mean	0.0774963
upper 95% Mean	20.441214
lower 95% Mean	20.137284
N	2453

Charter Boat Mode
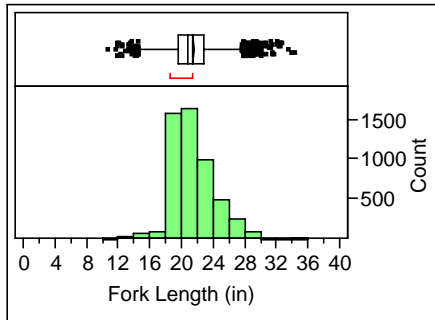
Mean	21.450108
Std Dev	2.7214621
Std Err Mean	0.0374991
upper 95% Mean	21.523621
lower 95% Mean	21.376594
N	5267

Shore Mode
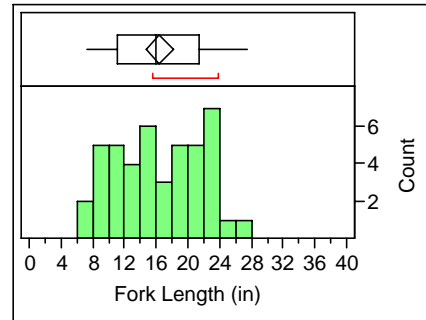
Mean	16.450429
Std Dev	5.4820655
Std Err Mean	0.8264525
upper 95% Mean	18.11713
lower 95% Mean	14.783729
N	44

Head Boat Mode
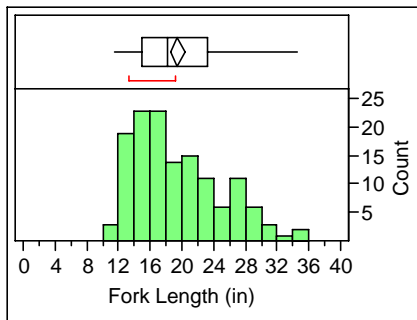
Mean	19.431289
Std Dev	5.5666397
Std Err Mean	0.4755901
upper 95% Mean	20.371798
lower 95% Mean	18.490781
N	137

Area: Inshore
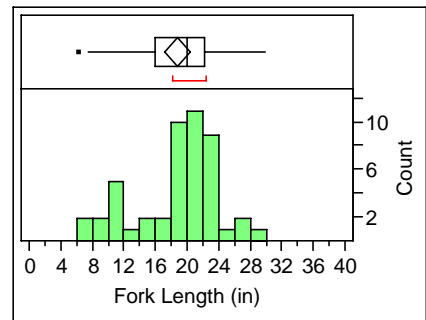
Mean	18.783629
Std Dev	5.4614363
Std Err Mean	0.7882904
upper 95% Mean	20.369464
lower 95% Mean	17.197793
N	48

Area: Less Than/Equal to 10 Miles
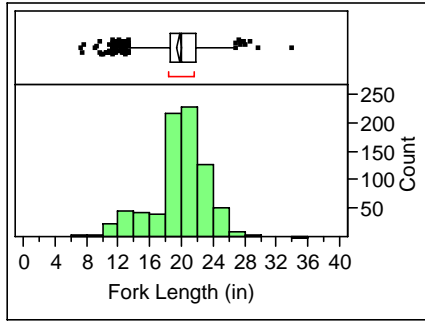
Mean	19.732706
Std Dev	3.522871
Std Err Mean	0.1243969
upper 95% Mean	19.976888
lower 95% Mean	19.488523
N	802

Area: Greater Than 10 Miles
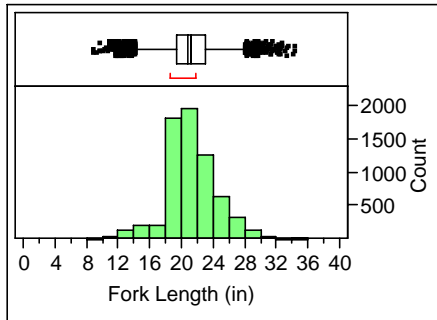
Mean	21.22282
Std Dev	3.198306
Std Err Mean	0.0388595
upper 95% Mean	21.298997
lower 95% Mean	21.146644
N	6774

Area: Greater Than 3 Miles
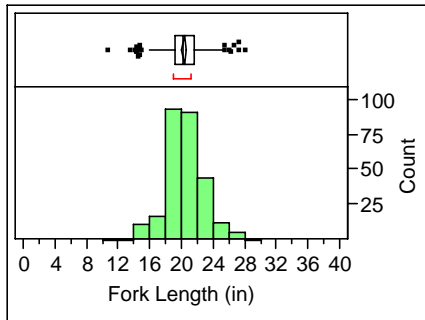
Mean	20.370107
Std Dev	2.4003989
Std Err Mean	0.144226
upper 95% Mean	20.65403
lower 95% Mean	20.086184
N	277

HEAD BOAT CHARTS
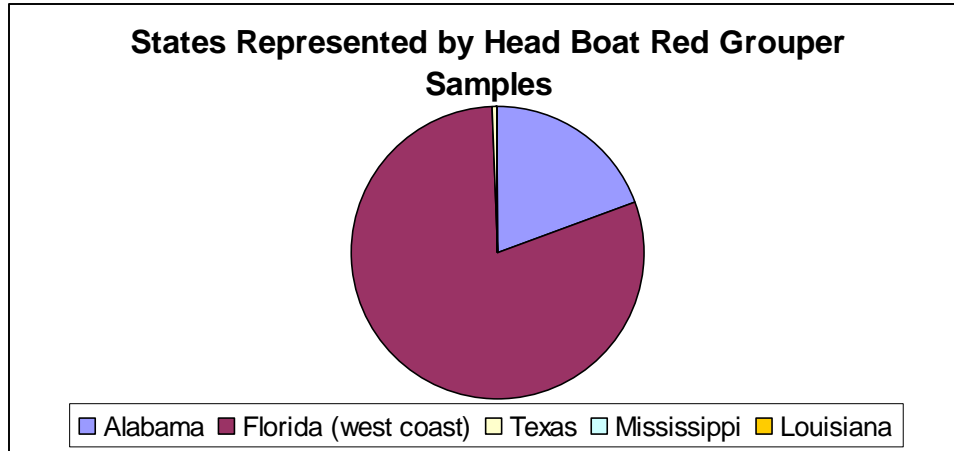
Figure 7: States where red grouper were sampled by the head boat survey.
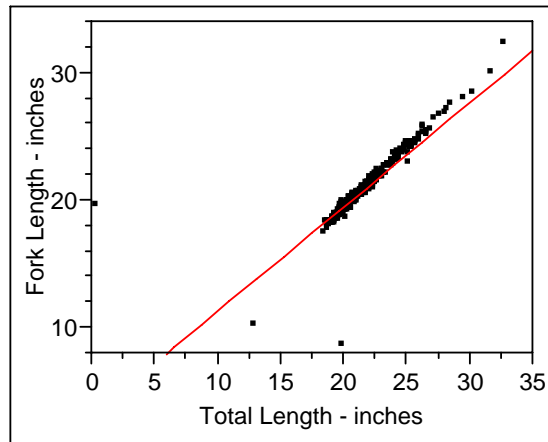
Figure 8: Initial linear fit to the available total and fork length data provided by the head boat survey. FL = 3.1115784 + 0.8171095*TL (n = 537).
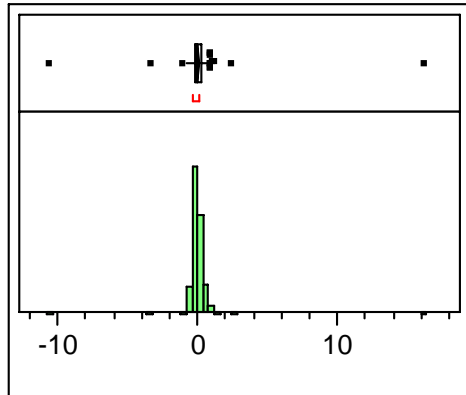
Quantile		
100.0%	maximum	16.20
99.5%		1.64
97.5%		0.84
90.0%		0.43
75.0%	quartile	0.20
50.0%	median	-0.0569
25.0%	quartile	-0.25
10.0%		-0.38
2.5%		-0.59
0.5%		-1.72
0.0%	minimum	-10.62

Moment

Mean	1.231e-15
Std Dev	0.919646
Std Err Mean	0.0396857
upper 95% Mean	0.0779585
lower 95% Mean	-0.077958
N	537

Figure 9: Residuals estimated from the initial linear fit of fork length to total length.
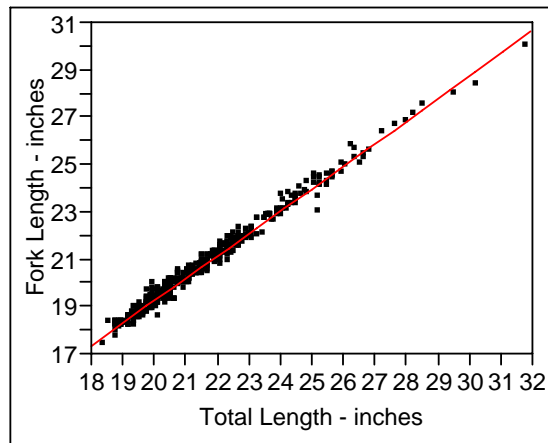
Figure 10: Final linear fit to the available total and fork length data without residuals provided by the head boat survey. FL = 0.3377252 + 0.9460861*TL (n = 533).
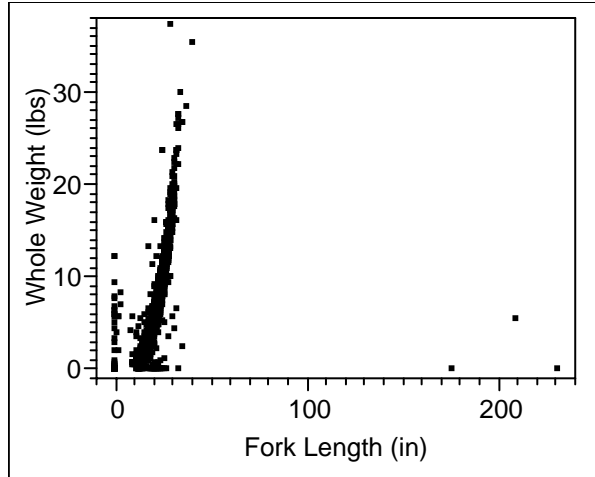
Figure 11: Head boat Gulf of Mexico raw red grouper length and weight data (n = 5,889).
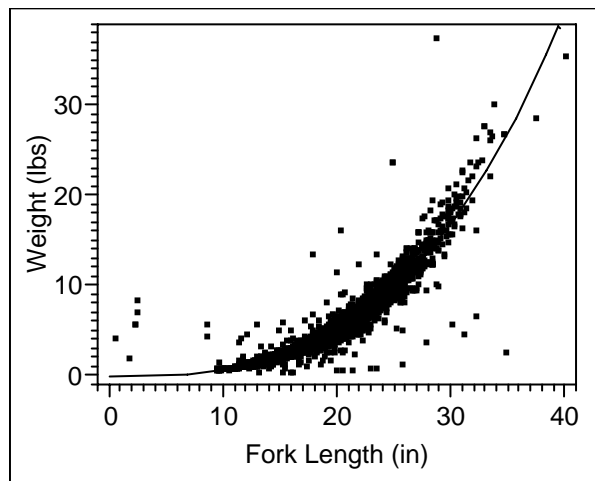
Parameter	Estimate	Low	High
a	0.0840804998	0.08266	0.0855
b	3.0517540562	2.98053	3.12297

Figure 12: Initial fork length to whole weight fit of head boat data after the removal of records containing a zero in the length and/or weight field (n = 5,770).
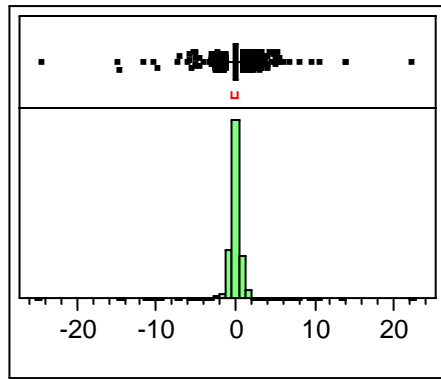
Quantile

100.0%	maximum	22.39
99.5%		3.62
97.5%		1.53
90.0%		0.70
75.0%	quartile	0.26
50.0%	median	-0.066
25.0%	quartile	-0.31
10.0%		-0.67
2.5%		-1.35
0.5%		-2.76
0.0%	minimum	-24.47

Moment

Mean	-0.012865
Std Dev	1.0046421
Std Err Mean	0.0132258
upper 95% Mean	0.0130629
lower 95% Mean	-0.038792
N	5770

Figure 13: Head boat length weight fit residuals for Gulf of Mexico red grouper.
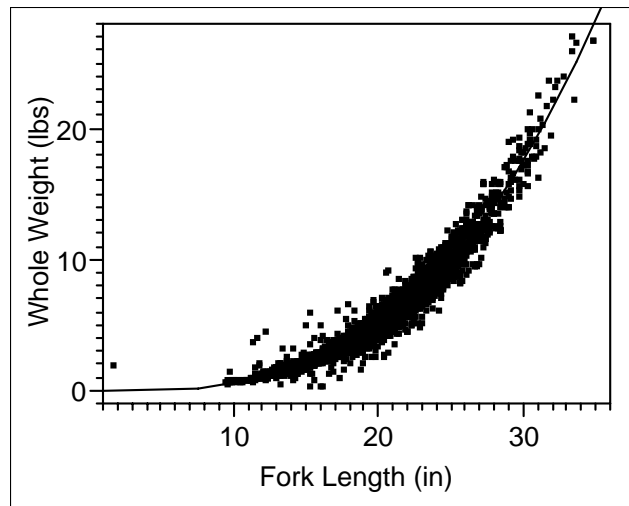
Parameter	Estimate	Low	High
a	0.0825897126	0.0817	0.08348
b	3.1433482865	3.09433	3.19236

Figure 14: Head boat final length width fit and parameter estimation with residuals removed (n = 5,714).

Head Boat Length Frequency Distributions
INCLUDING AREAS 12 AND 17

1986
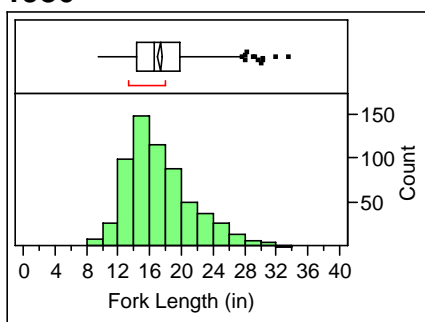
Mean	17.290356
Std Dev	4.1551754
Std Err Mean	0.1655462
upper 95% Mean	17.615446
lower 95% Mean	16.965266
N	630

1987

Mean	17.740877
Std Dev	3.7882176
Std Err Mean	0.1374131
upper 95% Mean	18.010632
lower 95% Mean	17.471122
N	760

1988

Mean	17.867409
Std Dev	3.9426387
Std Err Mean	0.1820541
upper 95% Mean	18.225154
lower 95% Mean	17.509664
N	469

1989

Mean	17.184105
Std Dev	4.3703997
Std Err Mean	0.1499035
upper 95% Mean	17.47833
lower 95% Mean	16.88988
N	850

1990

Mean	21.244053
Std Dev	3.9103997
Std Err Mean	0.2096194
upper 95% Mean	21.656338
lower 95% Mean	20.831769
N	348

1991
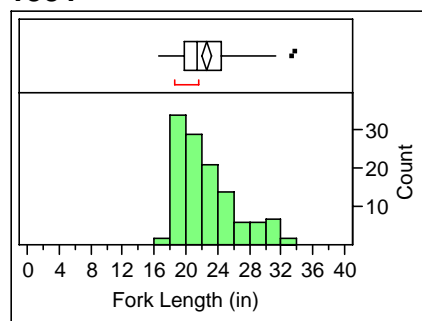
Mean	22.639733
Std Dev	3.7523714
Std Err Mean	0.3411247
upper 95% Mean	23.315136
lower 95% Mean	21.96433
N	121

1992
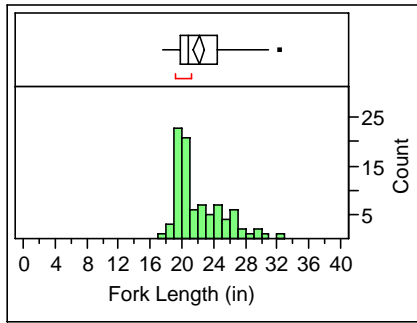
Mean	22.182547
Std Dev	3.1919405
Std Err Mean	0.3364601
upper 95% Mean	22.851086
lower 95% Mean	21.514008
N	90

1995
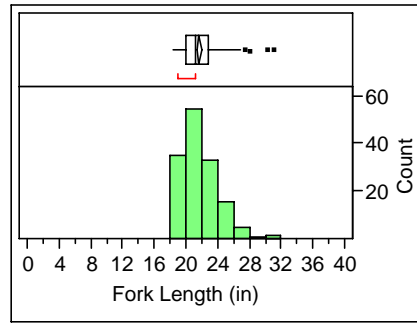
Mean	21.716768
Std Dev	2.3686185
Std Err Mean	0.1953604
upper 95% Mean	22.102867
lower 95% Mean	21.330668
N	147

1993
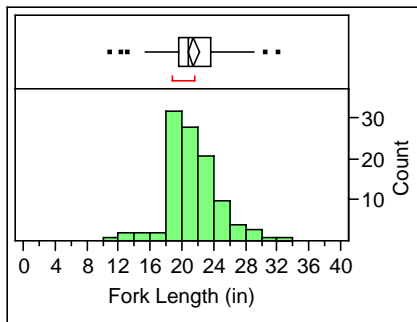
Mean	21.493252
Std Dev	3.3997095
Std Err Mean	0.3286623
upper 95% Mean	22.144857
lower 95% Mean	20.841647
N	107

1996
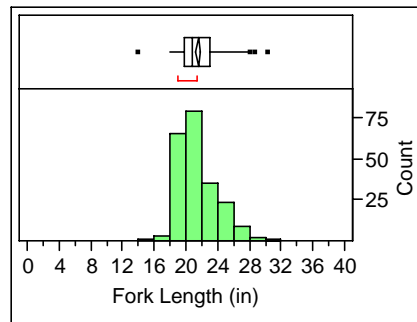
Mean	21.527517
Std Dev	2.4698411
Std Err Mean	0.1657649
upper 95% Mean	21.854199
lower 95% Mean	21.200835
N	222

1994
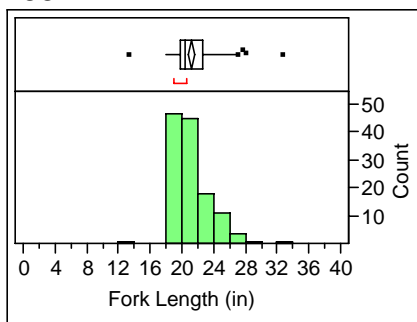
Mean	21.204464
Std Dev	2.5468847
Std Err Mean	0.2251149
upper 95% Mean	21.649926
lower 95% Mean	20.759002
N	128

1997
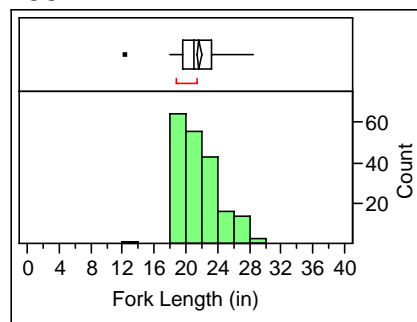
Mean	21.680534
Std Dev	2.621184
Std Err Mean	0.1862794
upper 95% Mean	22.047891
lower 95% Mean	21.313176
N	198

1998
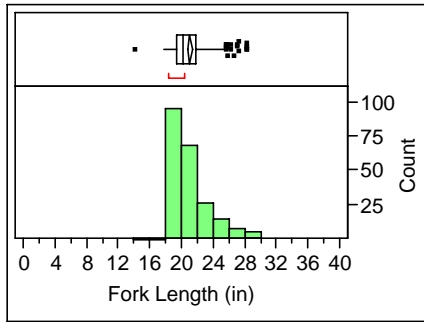
Mean	21.050023
Std Dev	2.4894369
Std Err Mean	0.1674577
upper 95% Mean	21.38005
lower 95% Mean	20.719997
N	221

2001
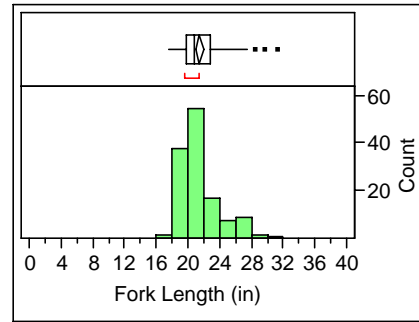
Mean	21.502479
Std Dev	2.5503979
Std Err Mean	0.2219836
upper 95% Mean	21.941616
lower 95% Mean	21.063343
N	132

1999
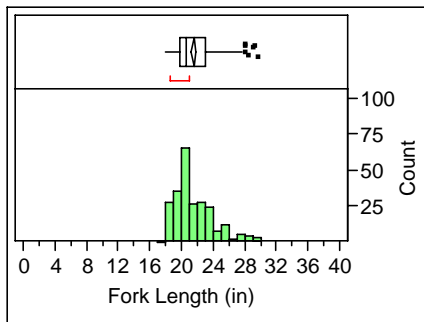
Mean	21.523163
Std Dev	2.47875
Std Err Mean	0.1600026
upper 95% Mean	21.838359
lower 95% Mean	21.207968
N	240

2002
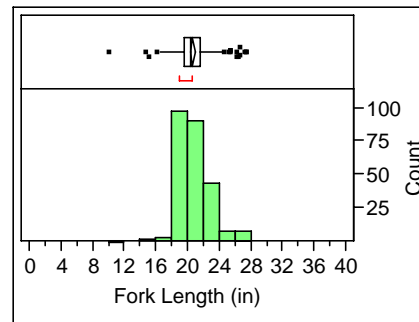
Mean	20.685778
Std Dev	2.0651491
Std Err Mean	0.1293247
upper 95% Mean	20.940464
lower 95% Mean	20.431093
N	255

2000
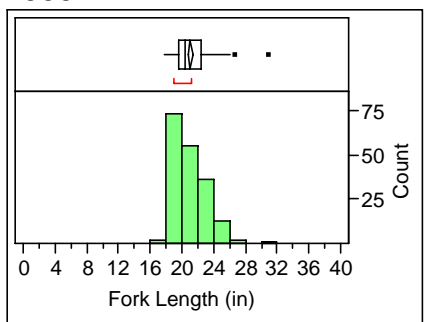
Mean	21.081353
Std Dev	2.0950002
Std Err Mean	0.1540275
upper 95% Mean	21.38524
lower 95% Mean	20.777465
N	185

2003
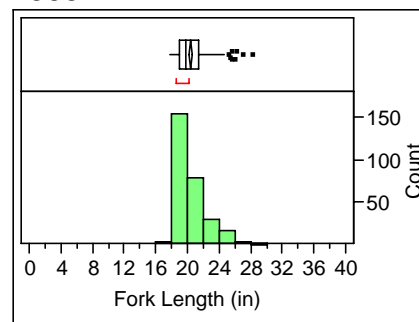
Mean	20.411749
Std Dev	1.8954184
Std Err Mean	0.1120784
upper 95% Mean	20.632356
lower 95% Mean	20.191143
N	286

2004
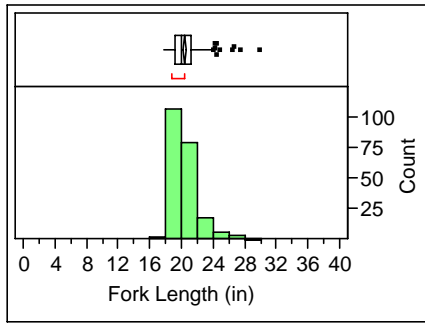
Mean	20.459516
Std Dev	1.7523901
Std Err Mean	0.1186868
Upper 95% Mean	20.693442
Lower 95% Mean	20.225589
N	218

Spring
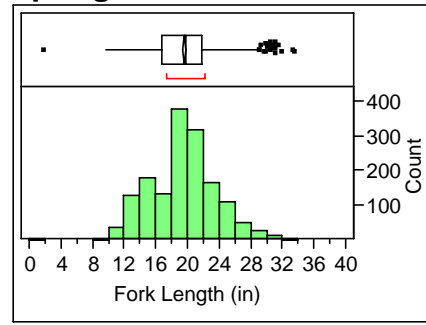
Mean	19.525761
Std Dev	4.0611502
Std Err Mean	0.1035213
upper 95% Mean	19.728819
lower 95% Mean	19.322704
N	1539

2005
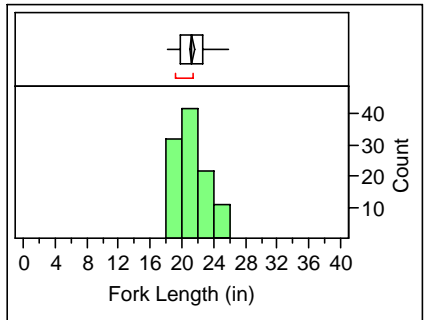
Mean	21.277136
Std Dev	1.8062954
Std Err Mean	0.1746212
Upper 95% Mean	21.623339
Lower 95% Mean	20.930932
N	107

Summer
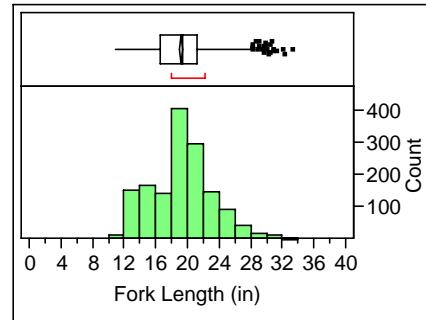
Mean	19.276788
Std Dev	3.8585208
Std Err Mean	0.1001285
upper 95% Mean	19.473197
lower 95% Mean	19.08038
N	1485

Fall
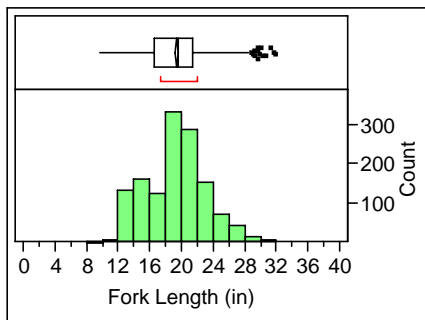
Mean	19.33724
Std Dev	3.8213835
Std Err Mean	0.1044702
Upper 95% Mean	19.542183
Lower 95% Mean	19.132296
N	1338

Winter
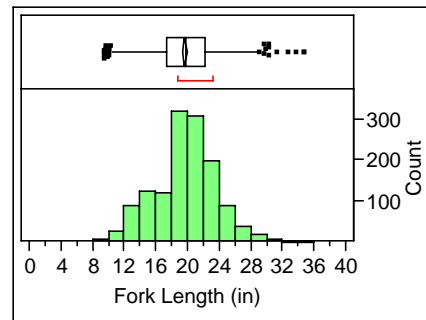
Mean	19.696002
Std Dev	3.8793262
Std Err Mean	0.1055428
upper 95% Mean	19.903048
lower 95% Mean	19.488956
N	1351

DOES NOT INCLUDE AREAS 12 AND 17

1986
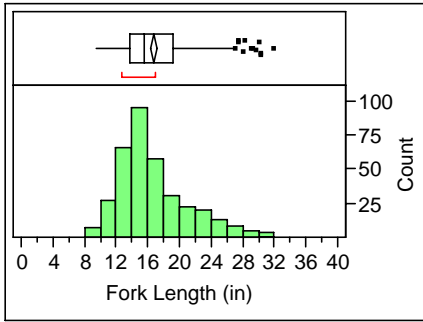
Mean	16.744414
Std Dev	4.4675074
Std Err Mean	0.2354583
upper 95% Mean	17.207465
lower 95% Mean	16.281363
N	360

1987

Mean	17.271749
Std Dev	3.7703163
Std Err Mean	0.1617998
upper 95% Mean	17.58958
lower 95% Mean	16.953917
N	543

1988

Mean	17.682302
Std Dev	4.0689862
Std Err Mean	0.2184346
upper 95% Mean	18.111929
lower 95% Mean	17.252675
N	347

1989

Mean	16.419118
Std Dev	4.3508501
Std Err Mean	0.1682136
upper 95% Mean	16.749409
lower 95% Mean	16.088827
N	669

1990

Mean	21.447699
Std Dev	4.3508011
Std Err Mean	0.279104
upper 95% Mean	21.997482
lower 95% Mean	20.897915
N	243

1991
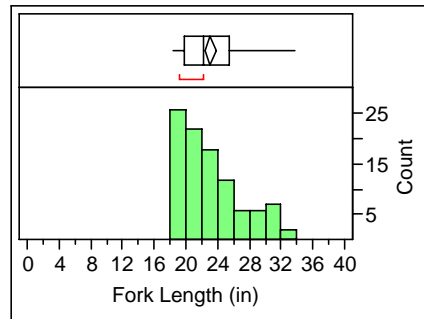
Mean	23.117007
Std Dev	3.8856674
Std Err Mean	0.3905243
upper 95% Mean	23.89199
lower 95% Mean	22.342025
N	99

1992
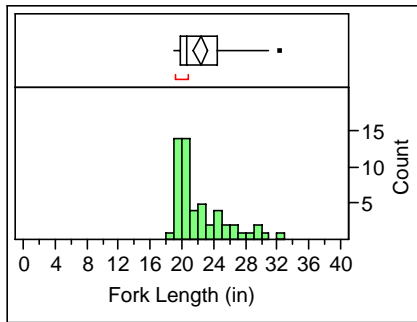
Mean	22.334434
Std Dev	3.4002479
Std Err Mean	0.4627151
upper 95% Mean	23.262523
lower 95% Mean	21.406345
N	54

1993

Mean	22.233238
Std Dev	4.6486601
Std Err Mean	0.834924
upper 95% Mean	23.938381
lower 95% Mean	20.528096
N	31

1994

Mean	20.907648
Std Dev	2.8935841
Std Err Mean	0.4012679
upper 95% Mean	21.713227
lower 95% Mean	20.102069
N	52

1995

Mean	21.833444
Std Dev	2.7267245
Std Err Mean	0.3611635
upper 95% Mean	22.556942
lower 95% Mean	21.109947
N	57

1996

Mean	21.31278
Std Dev	2.6334181
Std Err Mean	0.3125292
upper 95% Mean	21.9361
lower 95% Mean	20.68946
N	71

1997
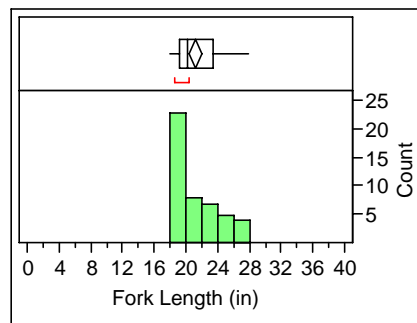
Mean	21.306474
Std Dev	2.751922
Std Err Mean	0.4014091
upper 95% Mean	22.114468
lower 95% Mean	20.498479
N	47

1998
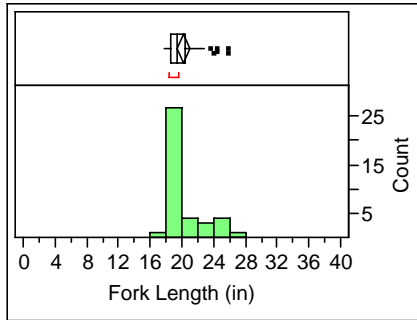
Mean	20.197153
Std Dev	2.2566753
Std Err Mean	0.3568117
upper 95% Mean	20.918872
lower 95% Mean	19.475433
N	40

1999

Mean	21.792627
Std Dev	2.7104466
Std Err Mean	0.2632618
upper 95% Mean	22.314627
lower 95% Mean	21.270628
N	106

2000

Mean	20.996583
Std Dev	2.3603319
Std Err Mean	0.2841506
upper 95% Mean	21.563597
lower 95% Mean	20.42957
N	69

2001

Mean	21.102481
Std Dev	2.3955243
Std Err Mean	0.3321994
upper 95% Mean	21.7694
lower 95% Mean	20.435563
N	52

2002

Mean	20.261664
Std Dev	1.83004
Std Err Mean	0.161126
upper 95% Mean	20.58048
lower 95% Mean	19.942849
N	129

2003
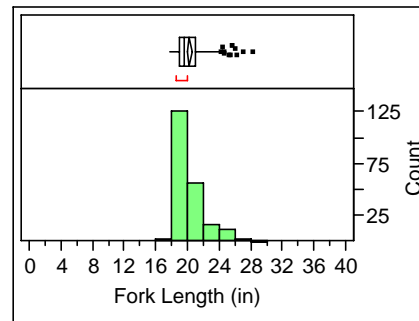
Mean	20.267804
Std Dev	1.9402883
Std Err Mean	0.1317153
upper 95% Mean	20.527416
lower 95% Mean	20.008193
N	217

2004
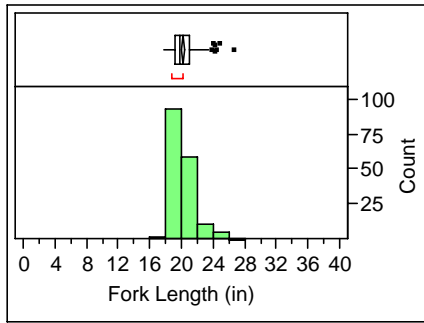
Mean	20.234847
Std Dev	1.5000981
Std Err Mean	0.1143814
upper 95% Mean	20.460628
Lower 95% Mean	20.009066
N	172

Spring
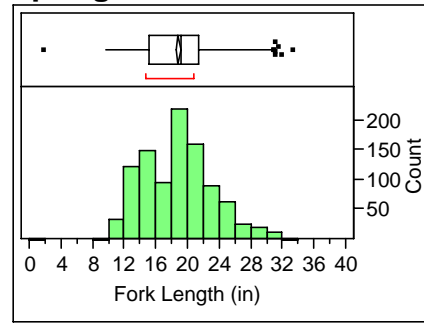
Mean	18.883243
Std Dev	4.4081354
Std Err Mean	0.1396771
upper 95% Mean	19.157338
lower 95% Mean	18.609147
N	996

2005
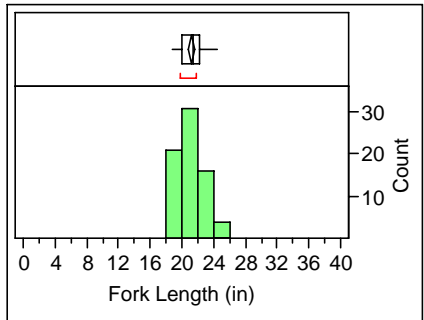
Mean	21.222113
Std Dev	1.5176993
Std Err Mean	0.1788626
upper 95% Mean	21.578755
Lower 95% Mean	20.865471
N	72

Summer
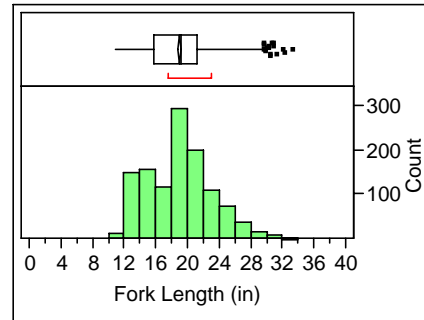
Mean	19.014065
Std Dev	4.1262808
Std Err Mean	0.120019
upper 95% Mean	19.249539
lower 95% Mean	18.77859
N	1182

Fall
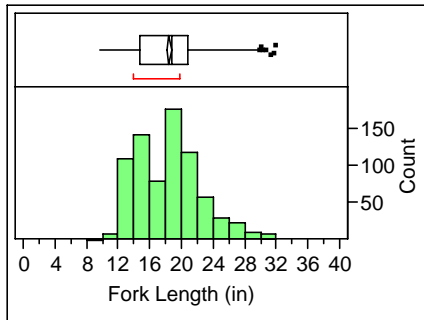
Mean	18.442682
Std Dev	4.077636
Std Err Mean	0.1477172
upper 95% Mean	18.732664
Lower 95% Mean	18.152701
N	762

Winter
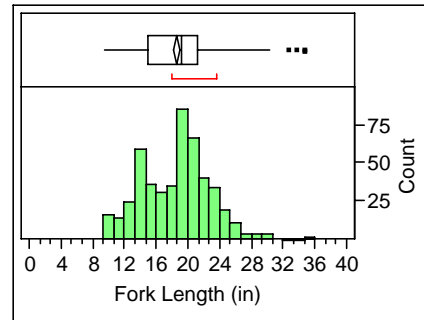
Mean	18.612044
Std Dev	4.4476061
Std Err Mean	0.2011277
upper 95% Mean	19.007227
lower 95% Mean	18.216861
N	489

Area 12
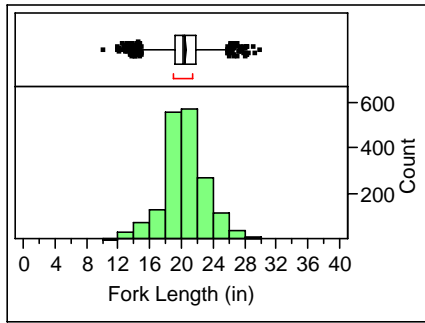
Mean	20.459182
Std Dev	2.726775
Std Err Mean	0.0640929
upper 95% Mean	20.584886
Lower 95% Mean	20.333478
N	1810

Area 21
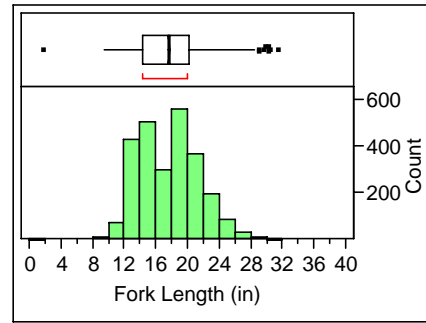
Mean	17.673409
Std Dev	3.7721594
Std Err Mean	0.0745102
upper 95% Mean	17.819515
lower 95% Mean	17.527303
N	2563

Area 17
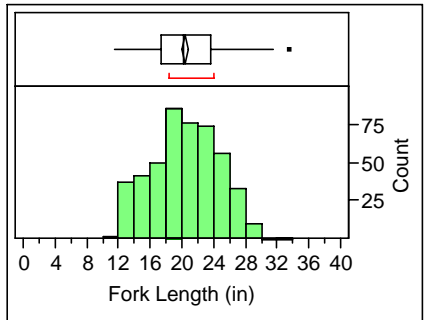
Mean	20.444378
Std Dev	4.184027
Std Err Mean	0.1921787
upper 95% Mean	20.822008
Lower 95% Mean	20.066748
N	474

Area 22
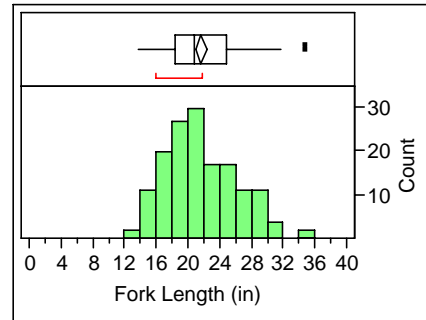
Mean	21.704251
Std Dev	4.5051793
Std Err Mean	0.3654183
upper 95% Mean	22.426244
lower 95% Mean	20.982257
N	152

Area 18
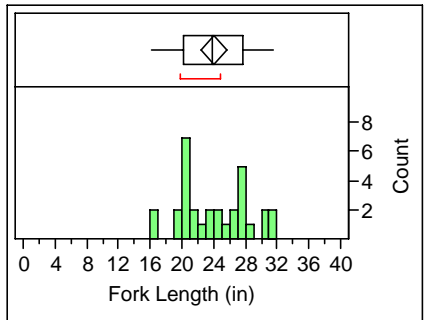
Mean	24.01511
Std Dev	4.3065393
Std Err Mean	0.7734773
upper 95% Mean	25.594761
Lower 95% Mean	22.435458
N	31

Area 23
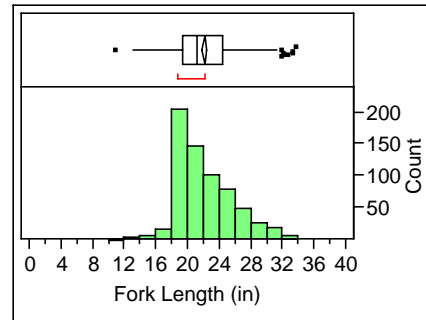
Mean	22.152373
Std Dev	3.6192969
Std Err Mean	0.1401397
upper 95% Mean	22.427542
lower 95% Mean	21.877204
N	667

Area 25
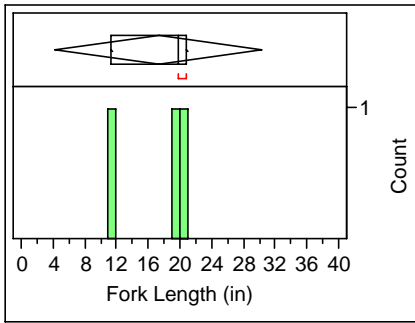
Mean	17.34741
Std Dev	5.235668
Std Err Mean	3.0228143
upper 95% Mean	30.35353
lower 95% Mean	4.3412894
N	3

Area 26
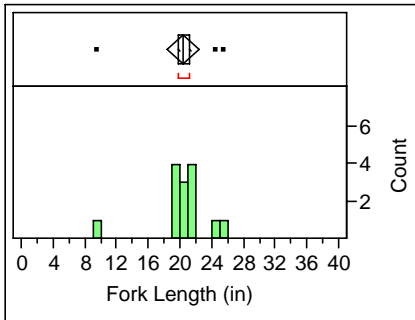
Mean	20.342285
Std Dev	3.5445669
Std Err Mean	0.9473253
upper 95% Mean	22.388857
lower 95% Mean	18.295713
N	14