Age, length, and growth of gag (*Mycteroperca microlepis*) from the northeastern Gulf of Mexico: 1978-2012

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SEDAR33-DW22

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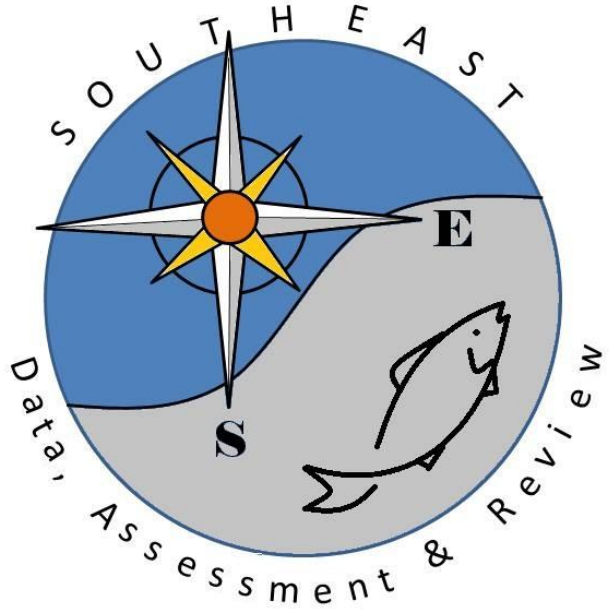

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Abstract

Gag were sampled for age structure from both the commercial and recreational harvests of the Gulf of Mexico primarily from the west coast of Florida as well as from fishery independent surveys (n = 31,844; 1991-2012, n = 824; 1978-1990). This dataset builds on previously reported age information. Reader comparisons revealed consistent age interpretation occurred between earlier and more recent time periods. Gag fully recruited into the fishery by ages 3-6 yrs old (range: 0 – 31 yrs, 6 ± 3 yrs) and became rare at age 13 yrs old (<1% of samples). Annual age frequencies displayed eight dominant age classes (1985, 1989, 1993, 1996, 1999, 2002, 2006, and 2007). A size-modified von Bertalanffy model that takes into account non-random sampling due to minimum size restrictions predicted the following growth parameters: L_∞ = 1272 mm, k = 0.14, t_o = -0.33.

Introduction

Because age and growth information is critical to stock assessment, the goal of this report is to characterize gag grouper (*Mycteroperca microlepis*) age-length structure using 34 years of data collected from the northeastern Gulf of Mexico: 1978-2012. Gag otoliths have been sampled and aged at the National Marine Fisheries Service- Southeastern Fisheries Science Center in Panama City, Florida, since 1979 (Johnson et al. 1993). Although there have been periods of low sampling effort, there is a continuous 22 year dataset: 1991 – 2012. This report includes a summary of data that has been provided for both the assessment in 2006 (SEDAR10; Lombardi et al. 2006) and the update assessment of gag grouper in 2010 (Lombardi et al. 2009). The following are discussed: meristic regressions, annual age and length data, annual age and length frequencies, and size-modified growth curve.

Methods

Data Collection

Otoliths were collected by numerous federal and state sources representing both the commercial and recreational fisheries (Trip Interview Program – TIP, Beaufort Head Boat Survey – HB, Marine Fisheries Recreational Statistical Survey – MRFSS, Recreational Fisheries Information Network – RECFIN). Gag otoliths were also collected from federally funded fishery independent surveys (NMFS Panama City, FL – PCLAB, and NMFS Pascagoula, MS – MSLAB) and state funded fishery independent surveys (Florida Fish and Wildlife Research Institute -Fishery Independent Monitoring, St. Petersburg, FL – FWRI-FIM). The Cooperative Research Program (CO-OP) also provided otoliths and gonads and site specific detailed capture locations. At-sea collection of otoliths and gonads were made possible through two observer

programs (NMFS Panama City Shark Bottom Long-line Observer Program – SBLOP and NMFS Galveston Reef fish Observer Program – GOP). Measurements of fish lengths (total and/or fork), weights (whole or gutted), and removal of otoliths were completed in the field.

Data Quality Control

Each of the data collection sources has separate but similar sampling procedures, data protocols, and reporting methodologies. Our facility uses data quality control guidelines in the interpretation of source-specific datasheets as described by the Procedure Manual for Age, Growth, and Reproduction (AGR) Lab (NMFS 2008). First, each species-specific collection is assigned an annual collection (or tracking) number and all collection-specific data (i.e. source, source number, state, sector, and gear) are proofed and entered in our Annual AGR Access Databases from the original datasheets. If such data are not provided, then the collector (port agent and/or survey leader) is contacted to track down the missing data. Our Annual AGR Access Databases were constructed with field-specific lists of suitable values (e.g. source, state, sector, and gear), validation rules, and user-specific security for data accessibility to enhance our data quality control procedures. Additionally, the source number (or interview number) is a source-specific number (or combination of intercept specific numbers) that permits the cross-referencing of data between databases (original source and Annual AGR Database). Next, after all the individual fish data are entered, proofing sheets are reviewed against the original datasheets and any corrections are made to the Annual AGR Database. Finally, all proofing sheets are initialed, dated and filed for further reference. Prior to 1998, no manual existed to implement these procedures. Therefore, to insure these standards of quality control, all 1991-1997 data were proofed using the TIP original datasheets (archived in Panama City, FL) and any

missing data were resolved by accessing the TIP database (TIP-ONLINE, DELPHI, SEFHOST). Beginning in 2011, all TIP data is reported electronically via the TIP-ONLINE program and our facility ages are entered directly into a joint database (NMFS Biological Sampling Database); therefore, our facility no longer proofs these records.

Age Determination

Annual ages, based on a calendar year, were calculated using the reader's annulus count, edge type, and capture date (Jearld 1983). Annulus counts were advanced a year if the fish was captured between January 1 to June 30 and the edge type was determined to be fully translucent (edge type 6). Typically, marine fish in the southeastern U.S. complete annulus formation, an opaque zone, by late spring to early summer. Therefore, an otolith with two completed annuli and a large translucent zone would be classified as age 3 if the fish was caught during spring in expectation that a third (opaque zone) annulus would have formed soon. Any fish caught before June 30 with an opaque edge (type 2), the annual age was equal to the annulus count. After June 30, when opaque zone formation is underway or complete for gag in the Gulf of Mexico (Johnson and Koenig 2005), all fish were assigned an annual age equal to the annulus count by convention.

In addition to annual or cohort age, fractional age was calculated. A fractional period of a year was determined as the difference from peak spawning date (March 1, Collins et al. 1997) and capture date. If capture date was after the peak spawning date, the fractional period was added to annual age. If capture date was before the peak spawning date, the fractional period was subtracted from annual age to yield an estimate of fractional age.

Indices of Precision

Indices of precision or reader agreement (average percent error – APE) were derived for gag based on a reference collection maintained at the NMFS Panama City Laboratory. Multiple readers (6) participated in interpreting gag otoliths throughout the time period (1991-2012). Gag reader agreements were based on whole and sectioned otoliths.

Regressions

Meristic relationships were calculated for lengths and body weights for all gag caught from 1991 to 2012. A majority of gag grouper are reported in fork length (92%); therefore, only 8% of lengths needed to be converted from either natural or maximum total lengths to fork length. Conversions from natural total length (mm) and maximum total length to fork length were calculated through a linear regression (R, lm function). Conversions from natural and maximum total length (mm) to whole weight (kg) and gutted weight (kg) and from fork length (mm) to whole weight (kg) and gutted weight (kg) were calculated by a non-linear regression (R, nls function). Conversions among lengths and weights were compared to those conversions used in previous assessments.

Age & Growth Data

Age and length frequencies were produced for each year by species with all sectors and gears combined to examine annual trends in age structure during 1991-2012. Length and age data were also compared among years. Box plots were used to visually compare annual patterns of length and age.

Description of Growth

A growth curve, based on fractional ages and observed fork lengths at capture, was modeled using the von Bertalanffy growth model and was executed in ADMB (Auto Differentiate Model Builder). Since the majority of the data were derived from commercial and recreational samples, a size-modified von Bertalanffy model was used to predict growth parameters that take into account the non-random sampling due to minimum size restrictions (Diaz et al. 2004). This model assumes a constant standard deviation of size-at-age and uses a restrictive maximum likelihood estimation procedure with minimum size (1990-1999 CM and REC 20 TL in, 493 FL mm; 2000-2011 CM 24 TL in, 591 FL mm; 2012 CM 22 TL in, 542 FL mm; 2000-2012 REC 22 TL in, 542 FL mm) as the left truncation limit for fisheries dependent observations. Fishery independent data were used to aid the model to predict growth at smaller sizes not collected in fishery dependent sampling. This is the same method as was used in the previous assessments (Lombardi et al. 2006, Lombardi et al. 2009).

Results and Discussion

Data Collection

The majority of samples proportionally remained consistent by state, source, and by sector with previous years. Gag were primarily harvested from Florida waters (gag, 97%; Table 1) and by Trip Interview Program (TIP) port agents (gag, 77%; Table 2). Gag were intercepted more frequently from commercial hand-line vessels (39%; Table 3) than from other sectors. A majority of the gag otoliths collected in the field were aged (85%). Gag otoliths collected from the commercial hand-line and long-line were sub-sampled during 3 years (2005, 2006, 2008; Table 4).

Regressions

Meristic relationships were calculated for lengths and body weights for all gag combined 1991- 2012 (Table 5). The linear regression for converting length types (total and fork) was based on 4789 (maximum total lengths) and 1599 (natural total lengths) individual length measurements ($r^2 = 0.9973$, $r^2 = 0.9886$, respectively). The non-linear regressions predicting gutted weight (kg) from maximum total length had the highest correlation ($r^2 = 0.9460$, n = 540).

The comparison of linear regression resulted in similar regressions among length metrics (maximum and natural total lengths and fork lengths) (Figure 1). There were some differences among the non-linear regressions (Figure 2). The regressions for maximum and natural total lengths and gutted weight were dissimilar. This dissimilarity may be due to the regressions in SEDAR10 were calculated using Microsoft Excel, graphic trend line function. The comparisons of the regression for whole weight and fork length also showed some dissimilarity, this may be due to the additional 1400 fish used in the SEDAR33 regression.

Indices of Precision

The calculated indices of precision based on the reference set indicated no apparent ageing bias among secondary readers compared to the primary reader (Table 6). Average percent errors between the primary and secondary readers were well below the accepted 5% (Campana 2001). These APEs reflect reader precision not only for the current years but for the entire time series (1977-2012).

Age & Growth Data

An additional 11,759 gag otoliths (2005, 2008, 2009-2012) were aged and incorporated into the existing gag dataset (n = 20,085; 1991-2008). The fork length distribution of all gag aged continues to peak between 650 - 700 mm (Figure 3) with an overall mean fork length of 730 ± 163 mm (std. dev). Mean fork lengths differed among years, but fork lengths were more consistent in the more recent years (2008-2012) (Figure 4a).

The most recent age distribution indicates two strong year classes (2006 and 2007) progressions (as defined as, exceeding 30% of the total age structure during at least one year and dominating the age structure for two or more years within the time period, Lombardi et al. 2006; Figure 5, Table 7). Mean ages differed among years, but as with the lengths, showed some similarities in the most recent years (2008-2012) (Figure 4b). Annual age composition of gag continues to represent an extensive range (1 – 31 yrs; Figure 5), but more recent years (2007-2012) fewer (<20) fish older than 15 years are reported (Table 8).

Description of Growth

Gag data (observed total lengths and fractional ages) from the entire time series (1991-2012; n = 31,734) were fit to a size-modified von Bertalanffy growth model to obtain population growth parameters (Figure 6). Since this model takes in the affect of the minimum size limit, those records without a mode (commercial or recreational) of collection (n = 110) were not used in model fitting. The model fit resulted in the following growth parameters: L_∞ = 1272 mm, k = 0.1412, t_o = -0.3307 (Figure 6), these parameters are similar to those calculated during the 2006 and update assessments (Table 9). The size-modified von Bertalanffy growth model predicts the size-at-age to be lower than observed (Figure 6). This model corrects for the biased observations due to the minimum size limits and sample truncation at the smaller ages.

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Table 1. Summary of the number of gag otoliths aged and collected by state landed (AL – Alabama, FL – west coast Florida, MS – Mississippi, LA – Louisiana, TX - Texas).

Year	FL	AL	MS	LA	TX	Total
1978-1990	798				26	824
1991	319		2	25	11	357
1992	449		3	34	7	493
1993	666			147	14	827
1994	723			13	18	754
1995	646			5	6	657
1996	945				5	950
1997	276				1	277
1998	329	7	3	10		349
1999	503	13	4			520
2000	624		7	13	1	645
2001	1,791	2	11	16		1,820
2002	2,295	1	5	18	9	2,328
2003	2,035	2	3	7	4	2,051
2004	2,552	14	1	8	8	2,583
2005	1,898		2	29	5	1,934
2006	1,294			23	8	1,325
2007	1,487			11	13	1,511
2008	1,641	1		12	9	1,663
2009	2,575	2		40	6	2,623
2010	3,076	1		43	8	3,128
2011	2,447	1		47	3	2,498
2012	2,441	3	2	82	23	2,551
Total	31,810	47	43	583	185	32,668
Percent	97.4	0.1	0.1	1.8	0.6	

Table 2. Summary of the number of gag otoliths collected and aged by source (TIP - Trip Interview Program, RECFIN - Recreational Fisheries Information Network (GULFIN), FWRI-FIM - Florida Fish and Wildlife Research Institute - Fishery Independent Monitoring, HB - Beaufort Head Boat Survey, MRFSS - Marine Recreational Fisheries Statistical Survey, CO-OP - Cooperative Research Proposals, MSLAB -NMFS Pascagoula, MS, PCLAB - NMFS Panama City, FL, GOP – Galveston Observer Program, NMFS Galveston, TX, SBLOP – Shark Bottom Longline Program, NMFS Panama City, FL, Other – includes otoliths from Alabama Department of Marine Resources; Expanded Annual Stock Assessment, NMFS Pascagoula, MS; Florida State University; US Geological Survey; University of Texas – Marine Science Institution,).

Year	TIP	RECFIN	FWRI-FIM	HB	MRFSS	PCLAB	MSLAB	CO-OP	GOP	SBLOP	Other	Total
1978-1990				59							765	824
1991	321			36								357
1992	386			107								493
1993	753			74								827
1994	666			84		3	1					754
1995	573			83			1					657
1996	821			129								950
1997	204			60							13	277
1998	265			40	2	4					38	349
1999	392			11	44	54	7				12	520
2000	588			23		34						645
2001	1,580			33	117	72	14	2			2	1,820
2002	1,914	49		12	263	36	2	51			1	2,328
2003	1,676			74	228	65	6				2	2,051
2004	2,248	61		38	18	63	9	141			5	2,583
2005	1,508	145		88	27	68		98				1,934
2006	1,183	28	34	54	5	19	2					1,325
2007	1,354	36	53	16	23	15	1			13		1,511
2008	1,178	265	118	17	60	17				8		1,663
2009	1,633	392	278	10	27	31	4	247	1			2,623
2010	1,901	742	381	18	45	15	3			23		3,128
2011	1,962	378	88	9	19	23	1				18	2,498
2012	2,041	249	128	4	12	48			69			2,551
Total	25,147	2,345	1,080	1,079	890	567	51	539	70	44	856	32,668
Percent	77.0	7.2	3.3	3.3	2.7	1.7	0.2	1.6	0.2	0.1	2.6	

Table 3. Summary of the number of gag otoliths collected and aged by sector (CM - Commercial, CP - Charter Party, HB – Headboat, PR - Private, SS - Scientific Survey, TRN - Tournament) and gear (HL - Hand-Line, LL - Long-Line, VLL – Vertical Long-line, SP - Spear, TR - Trap, TRW – Trawl, CM Other – includes spear, trap, and unknown for CM, SS Other – includes vertical long-line, seine net, cast net, gill net, spear, and unknown, Other sector – includes undersized fish collected by observer, specifically in 1996 and unknown). *Most of the data collected in 1979-1990 was reported as 'recreational.'

Year	CM HL	CM LL	CM VLL	CM Other	CP HL	HB HL	PR HL	PR SP	SS HL	SS LL	SS TR	SS TRW	SS other	TRN	Other	Total
1978-1990	54			3	661	59							2		45	824
1991	210	7			78	38	1	4						14	5	357
1992	66	22			230	131	4	9	3					28		493
1993	417	12		1	281	89		11						16		827
1994	439	3		2	183	104	4	4	2		2			11		754
1995	284	31			199	101	2		26				1	13		657
1996	197	57		3	447	141	1								104	950
1997	34	6		2	162	70	2							1		277
1998	106	101		3	51	66	2				7			3	10	349
1999	145	243		2	84	11	15		14	2	2			2		520
2000	387	177		6	36	23			12		1			3		645
2001	745	867			127	31	5		24	12	1			8		1,820
2002	809	1,085		15	314	17	31		8	2	4		3	38	2	2,328
2003	520	1,117		3	180	74	77	4	38	5	16		2	15		2,051
2004	894	1,484			75	39	25		24	9	24		9			2,583
2005	740	857		9	119	127	3		17		50			12		1,934
2006	641	534		1	26	57	14	3			16	10	23			1,325
2007	408	936		2	36	25	20		4	1	7	44	8	20		1,511
2008	680	506			160	27	75	4	1		18	38	78		76	1,663
2009	1,027	772	39		158	198	48	33	118	4	36	80	88	22		2,623
2010	798	883	208	27	400	219	121	53	289	2	18	50	40	20		3,128
2011	1,436	518	5	11	255	24	122	3	75	14	17	7	6	5		2,498
2012	1,616	457	3	34	255	16	1		110		6	2	15	36		2,551
Total	12,653	10,675	255	124	4,517	1,687	573	128	765	51	225	231	275	267	242	32,668
Percent	38.7	32.7	0.8	0.4	13.8	5.2	1.8	0.4	2.3	0.2	0.7	0.7	0.8	0.8	0.7	

Table 4. Summary of gag otoliths collected, read, and determined unreadable (1991-2004) or not sub-sampled (2005-2006, 2008) or samples received after December 31, 2012. *2005-2006, 2008 years were sub-sampled for ageing (see Lombardi et al. 2009 for sub-sampling details). ^Only a portion of the otoliths were recovered.

Year	# otoliths	# otoliths read	# otoliths not read	% otoliths not read
1978-1990^	1,895	824	---	---
1991	363	357	6	2
1992	505	493	12	2
1993	836	827	9	1
1994	757	754	3	0
1995	659	657	2	0
1996	961	950	11	1
1997	280	277	3	1
1998	352	349	3	1
1999	531	520	11	2
2000	652	645	7	1
2001	1,837	1,820	17	1
2002	2,348	2,328	20	1
2003	2,066	2,051	15	1
2004	2,620	2,583	37	1
2005*	3,439	1,934	1,505	44
2006*	2,414	1,325	1,089	45
2007	1,564	1,511	53	3
2008*	2,795	1,663	1,132	41
2009	2,641	2,623	18	1
2010	3,297	3,128	169	5
2011	2,511	2,498	13	1
2012	2,932	2,551	381	13
Total	38,255	32,668	5,587	15

Table 5. Meristic regressions for gag from the Gulf of Mexico (1991-2012)

Conversion and units	Equation	Sample Size	r^2 values	Data Ranges
Natural TL (mm) to FL (mm)	FL = 13.15 + Natural TL * 0.96	1599	0.9886	FL (mm): 357 - 1304 Natural TL (mm): 370 - 1338
Maximum TL (mm) to FL (mm)	FL = 1.07 + Maximum TL * 0.97	4789	0.9973	FL (mm): 235 - 1240 Maximum TL (mm): 241-1287
Maximum TL (mm) to G. Wt (kg)	G. Wt = 7.31×10^{-09} * (maximum TL$^{\wedge 3.07}$)	540	0.9460	Maximum TL (mm): 446 - 1295 G. Wt (kg): 0.99 – 27.02
Natural TL (mm) to G. Wt (kg)	G. Wt = 3.50×10^{-11} * (natural TL$^{\wedge 3.85}$)	40	0.5902	Natural TL (mm): 551 - 1110 G. Wt (kg): 1.80 – 19.01
FL (mm) to G. Wt (kg)	G. Wt = 7.28×10^{-09} * (FL$^{\wedge 3.08}$)	9793	0.7942	FL (mm): 394 - 1040 G. Wt (kg): 0.73 – 33.10
Maximum TL (mm) to W. Wt (kg)	W. Wt = 1.05×10^{-08} * (maximum TL$^{\wedge 3.03}$)	4266	0.7357	Maximum TL (mm): 120 - 1360 W. Wt (kg): 0.02 – 32.74
Natural TL (mm) to W. Wt (kg)	W. Wt = 1.36×10^{-08} * (natural TL$^{\wedge 2.99}$)	1934	0.4848	Natural TL (mm): 290 - 1332 W. Wt (kg): 0.34 – 31.30
FL (mm) to W. Wt (kg)	W. Wt = 1.17×10^{-08} * (FL$^{\wedge 3.02}$)	5238	0.6683	FL (mm): 215 - 1321 W. Wt (kg):0.13 – 32.74

Table 6. Reader precision statistics for ageing gag. Results are based upon primary reader (Gary Fitzhugh, 1991-2012) compared to secondary readers for average percent error (APE) and coefficient of variation (CV). NOAA – National Oceanographic Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City, FL; FWRI – Florida Fish and Wildlife Conservation Commission, Florida Wildlife Research Institute, St. Petersburg, FL.

Secondary reader	Years	APE (%)	CV (%)
Allyn Johnson (NOAA)	1979-1980, 1991-1995	1.09	1.54
Laura Goetz (NOAA)	2007-2008	3.77	5.33
Bill Fable (NOAA)	1998, 2002, 2005	2.59	3.66
Debbie Fable (NOAA)	2009-2010	2.10	2.97
Elen Crow (NOAA)	2010-2012	3.19	4.51
Jessica Carroll (FWRI)	2006-2012 (FWRI otoliths)	1.81	2.57

Table 7. Annual observed proportions at age for gag sampled from the northeastern Gulf of Mexico for 1991-2012. Data combined from fishery dependent (commercial and recreational) and independent sources. Strong year classes (as defined as, exceeding 30% of the total age structure during at least one year and dominating the age structure for two or more years within the time period) in bold and corresponding color (1985 – yellow; 1989 – red; 1993 – blue; 1996 – green; 1999 – purple; 2002 – aqua; 2006 - maroon; 2007 – pink).

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	1%	5%	3%	2%	0%	1%	1%
1	1%	1%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	0%	0%	2%	6%	2%	1%	1%	0%	1%
2	13%	8%	4%	2%	10%	1%	3%	4%	2%	4%	1%	2%	2%	1%	1%	2%	2%	6%	8%	1%	2%	2%	3%
3	1%	**34%**	10%	12%	14%	**55%**	9%	11%	15%	6%	3%	12%	9%	4%	7%	3%	6%	11%	**23%**	19%	6%	3%	12%
4	11%	7%	**56%**	16%	11%	16%	**67%**	22%	9%	**42%**	10%	7%	17%	12%	11%	17%	13%	15%	22%	**37%**	**34%**	9%	19%
5	13%	23%	8%	**49%**	12%	8%	4%	**36%**	18%	12%	**45%**	20%	9%	**29%**	21%	17%	**29%**	16%	15%	17%	**34%**	**40%**	23%
6	**41%**	10%	10%	9%	**35%**	5%	3%	6%	**31%**	13%	9%	**36%**	25%	11%	**31%**	27%	14%	**24%**	9%	8%	13%	**28%**	18%
7	4%	12%	4%	4%	6%	10%	7%	5%	7%	11%	11%	6%	21%	16%	7%	15%	14%	5%	9%	4%	5%	10%	9%
8	5%	1%	6%	2%	3%	1%	4%	5%	6%	4%	9%	5%	4%	13%	8%	5%	8%	5%	3%	4%	2%	2%	5%
9	3%	0%	1%	3%	1%	1%	0%	1%	4%	1%	2%	4%	2%	3%	6%	4%	3%	2%	2%	2%	1%	2%	3%
10	3%	1%	0%	1%	4%	0%	0%	2%	2%	1%	3%	1%	2%	2%	2%	3%	3%	1%	1%	1%	1%	1%	2%
11	1%	0%	0%	1%	0%	0%	0%	0%	1%	1%	1%	1%	1%	2%	1%	1%	2%	1%	1%	1%	0%	0%	1%
12	1%	0%	0%	0%	1%	0%	2%	0%	1%	1%	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%	0%	0%	1%
13	0%	0%	0%	1%	1%	0%	0%	1%	1%	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	1%
14	0%	1%	0%	0%	1%	0%	1%	1%	0%	0%	1%	1%	1%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%
15	0%	0%	0%	0%	0%	1%	0%	1%	0%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
16	1%	0%	0%	0%	0%	0%	0%	1%	0%	1%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
17	1%	0%	0%	0%	0%	0%	0%	1%	1%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
18	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
20	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

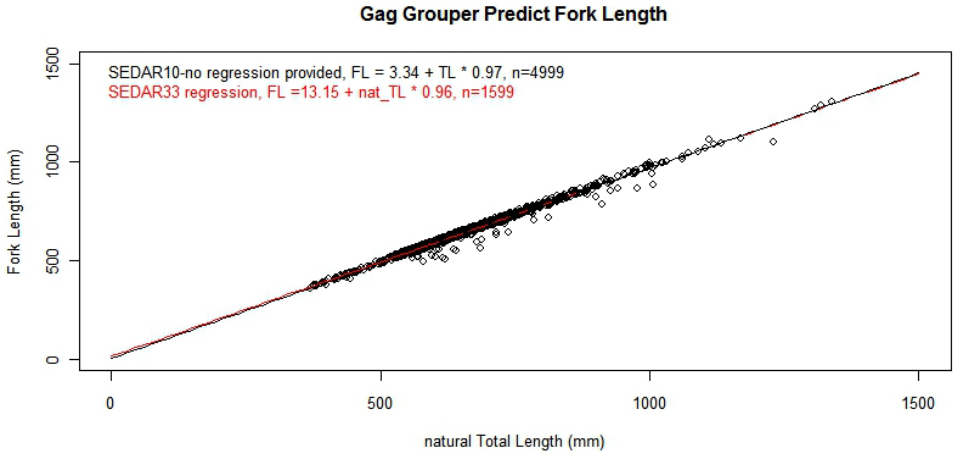
Table 8. Annual observed numbers at age for gag sampled from the northeastern Gulf of Mexico for 1991-2012. Data combined from fishery dependent (commercial and recreational) and independent sources.

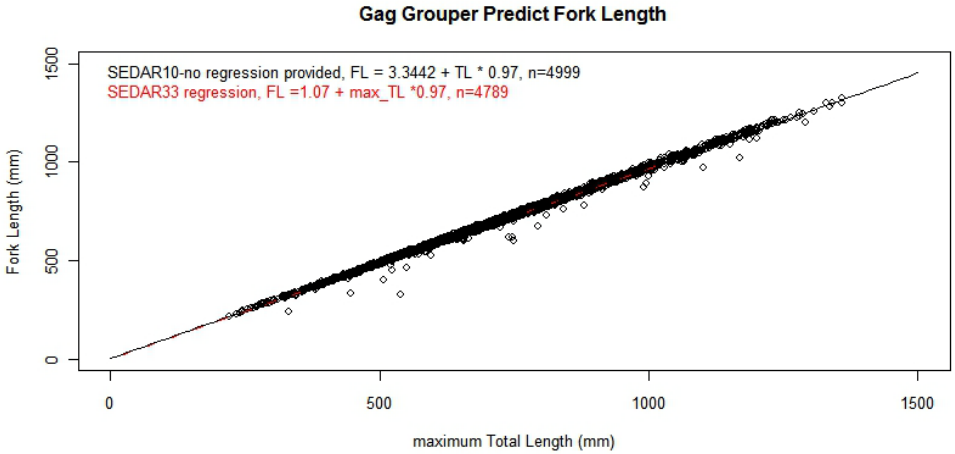
Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
0														1		32	13	78	89	51	2	15	281
1	5	3	1	2				5		1	1	6	12	8	6	1	24	107	47	16	22		267
2	45	39	31	15	66	12	8	14	10	25	11	47	31	29	25	23	33	92	196	46	41	53	892
3	5	166	80	92	89	522	24	39	76	40	56	281	180	108	136	39	83	185	611	602	152	86	3652
4	41	36	465	117	73	152	185	78	46	269	174	163	344	306	216	218	191	249	578	1162	859	241	6163
5	46	113	63	366	77	78	12	126	90	74	799	458	191	744	407	223	442	265	391	543	849	1031	7388
6	147	50	79	69	231	49	7	21	161	84	166	823	495	293	586	352	214	400	246	251	332	719	5775
7	16	61	34	30	42	97	19	19	36	70	191	144	431	403	134	203	213	88	236	140	122	246	2975
8	18	6	52	13	22	8	11	16	29	23	158	123	87	343	160	63	117	75	83	118	53	59	1637
9	9	2	9	19	7	9		5	23	7	42	88	48	89	109	58	40	40	53	74	30	39	800
10	10	3	3	7	26	3	1	7	12	9	46	27	42	49	46	45	51	15	29	43	15	26	515
11	2	1	1	9	3	3	1	1	7	6	23	17	25	48	28	15	36	14	16	20	11	10	297
12	3	2		1	5	4	5	1	5	4	22	18	23	25	15	5	18	23	15	24	1	3	222
13	1	1	2	8	4	3		4	6	2	22	26	21	24	12	11	10	6	10	7	1	7	188
14		4		1	4	4	2	3	2	3	23	14	21	29	5	9	7	8	4	10	2	2	157
15			2		2	5		3	2	5	19	14	14	25	10	4	4	5	2	8	1	4	129
16	2	1		2	1		1	2	2	6	7	16	13	12	5	2	3	1	1	3	1	4	85
17	3	2	1	1	2		1	3	4	2	10	14	11	9	6	6	2	2	2	4	1	1	87
18	2				1			1	2	1	7	10	12	11	8	2	3	2	2	1		1	66
19								1		1	10	10	9	5	3		1	1		1			42
20	2	2	2						1	1	7	8	9	3	2	4	2	2	2	1			48
21				1						1	7	3	8	10	1	4	1	1	1	1	1		40
22			2	1		1			2	1	6	7	7	6		2		1	3			1	40
23					1				1	3	5	3	7	1	4	1		2	2	1		1	32
24		1								2	1		3		4		2	1	1			1	16
25					1					1	4	2		1	1	1	1			1	2		15
26									1	1	1		2		3								8
27										1	2	3	2	1		1			1				11
28									2	2		2	1		1	1			1			1	11
29												1	2						1				4
31															1								1
Total	357	493	827	754	657	950	277	349	520	645	1820	2328	2051	2583	1934	1325	1511	1663	2623	3128	2498	2551	31844

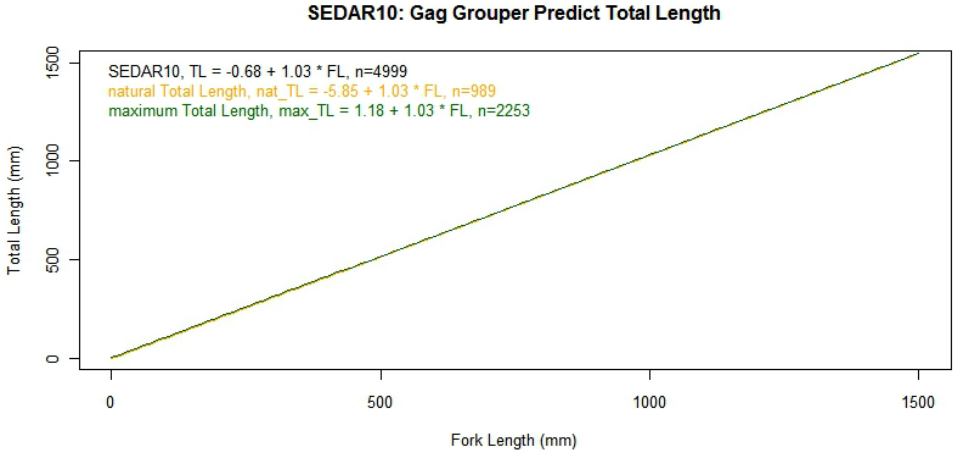
Table 9. Growth curve parameters (L_∞ - asymptotic length, k – growth coefficient, t0 – size at time zero, sigma – standard deviation for model) for gag from the northeastern Gulf of Mexico for biological ages and observed fork lengths at capture provided for the current (1991-2012) and previous size-modified growth curves (SEDAR10, years:1991-2005, Lombardi et al. 2006; update, years:1991-2008, Lombardi et al. 2009).

Model	n	L_∞	k	t_0	Sigma
current	31734	1272 (FL)	0.1412	-0.3307	76.7105
update	20507	1300 (TL)	0.1448	-0.3934	77.1723
SEDAR10	16436	1307 (TL)	0.1441	-0.3685	77.6044

Figure 1. Maximum and natural total length and fork length conversions compared between SEDAR10 and SEDAR33.







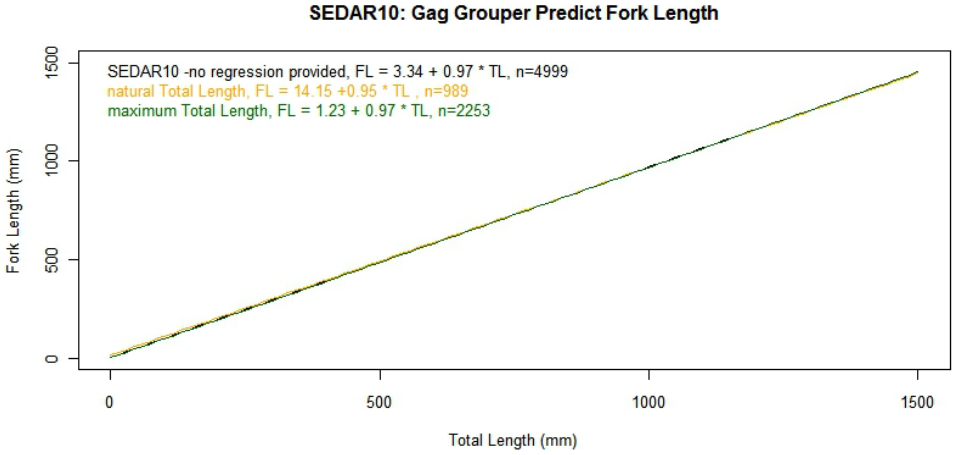


Figure 2. Maximum and natural total length (mm) and fork length (mm) and whole and gutted weight (kg) conversions compared between SEDAR10 and SEDAR33.

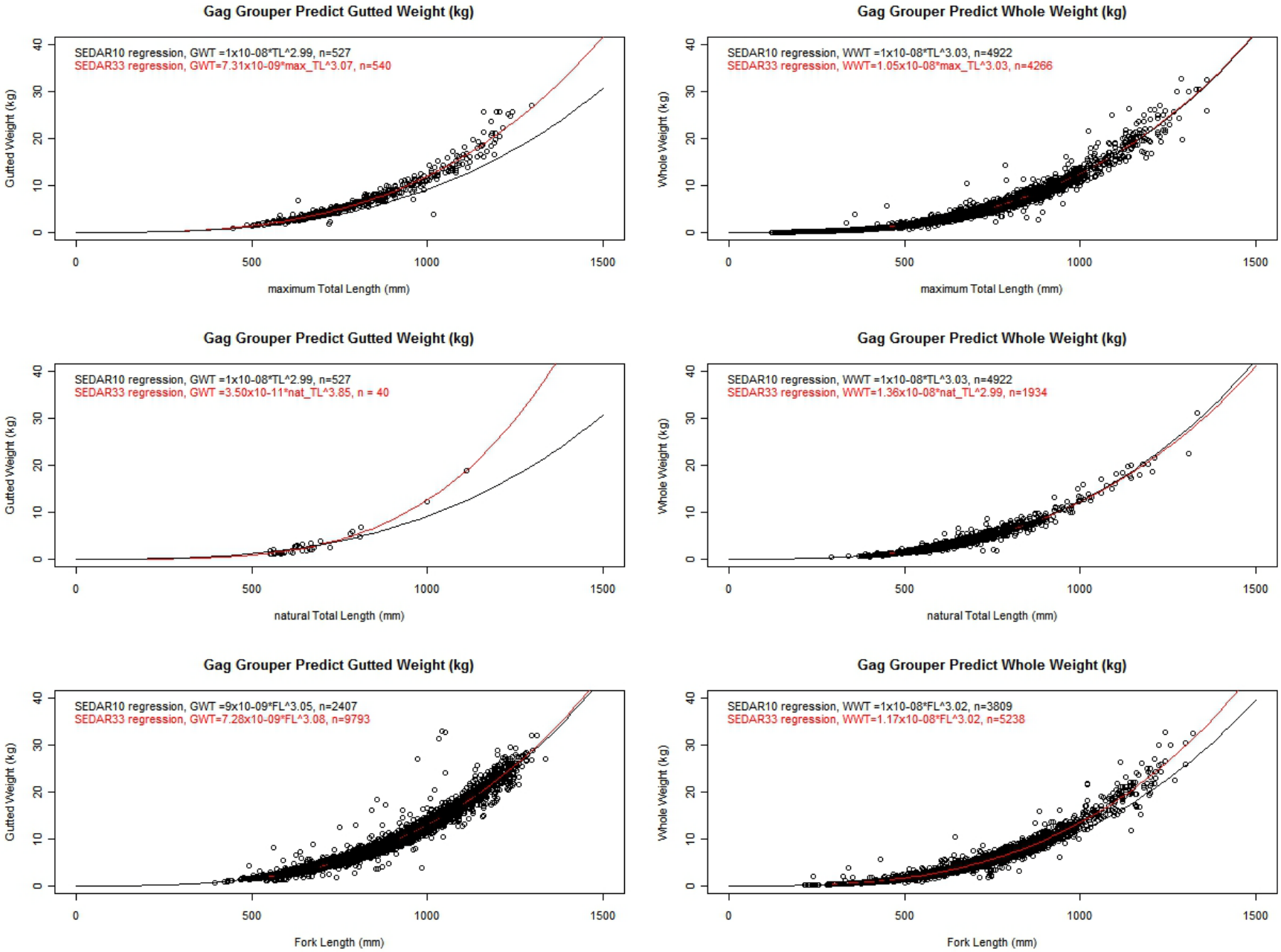


Figure 3. Observed length composition for gag aged from the northeastern Gulf of Mexico for 1991-2012. Data combined from fishery dependent (commercial and recreational) and independent sources. The trend lines indicate the normal distribution.

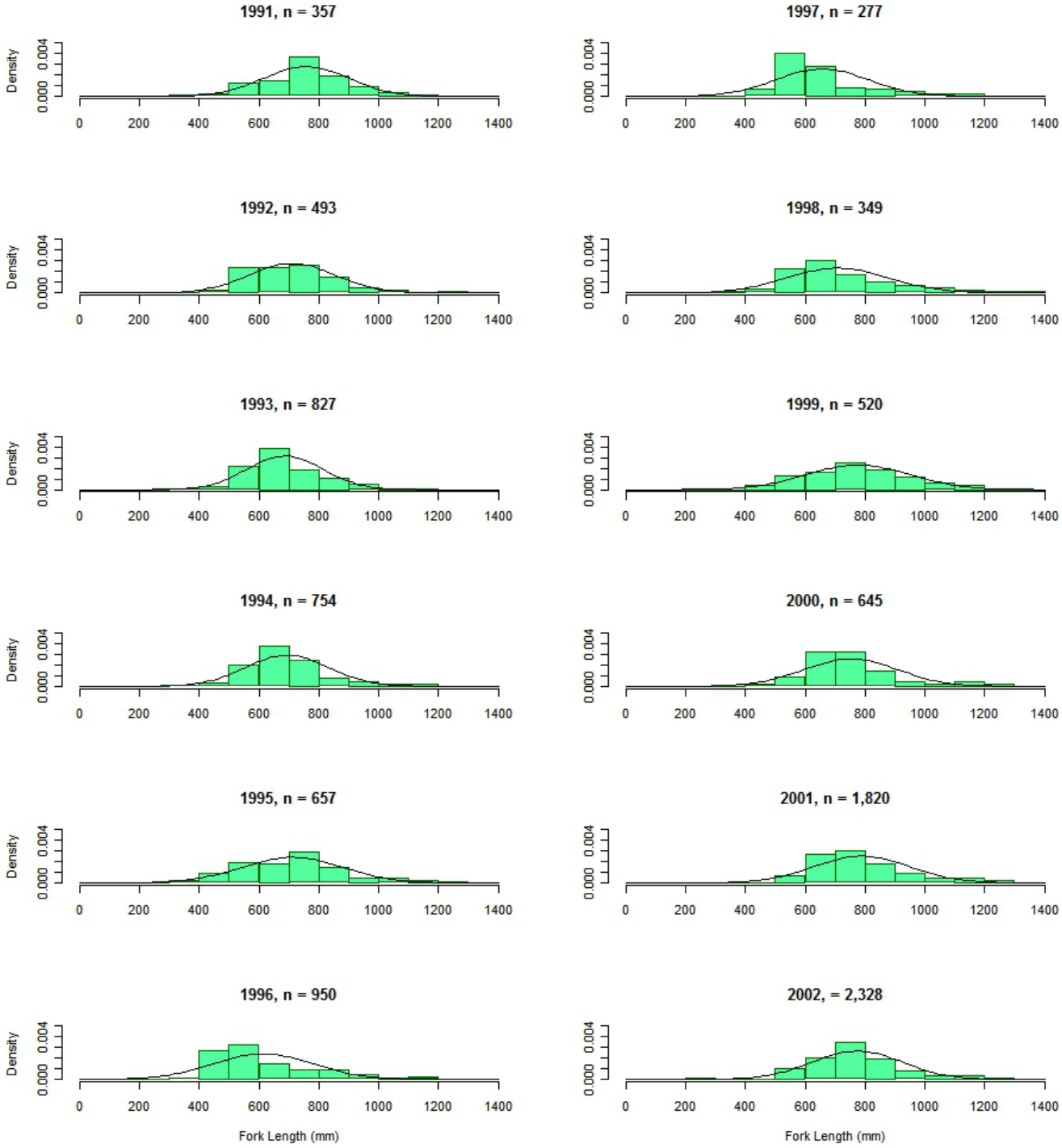


Figure 3. continued

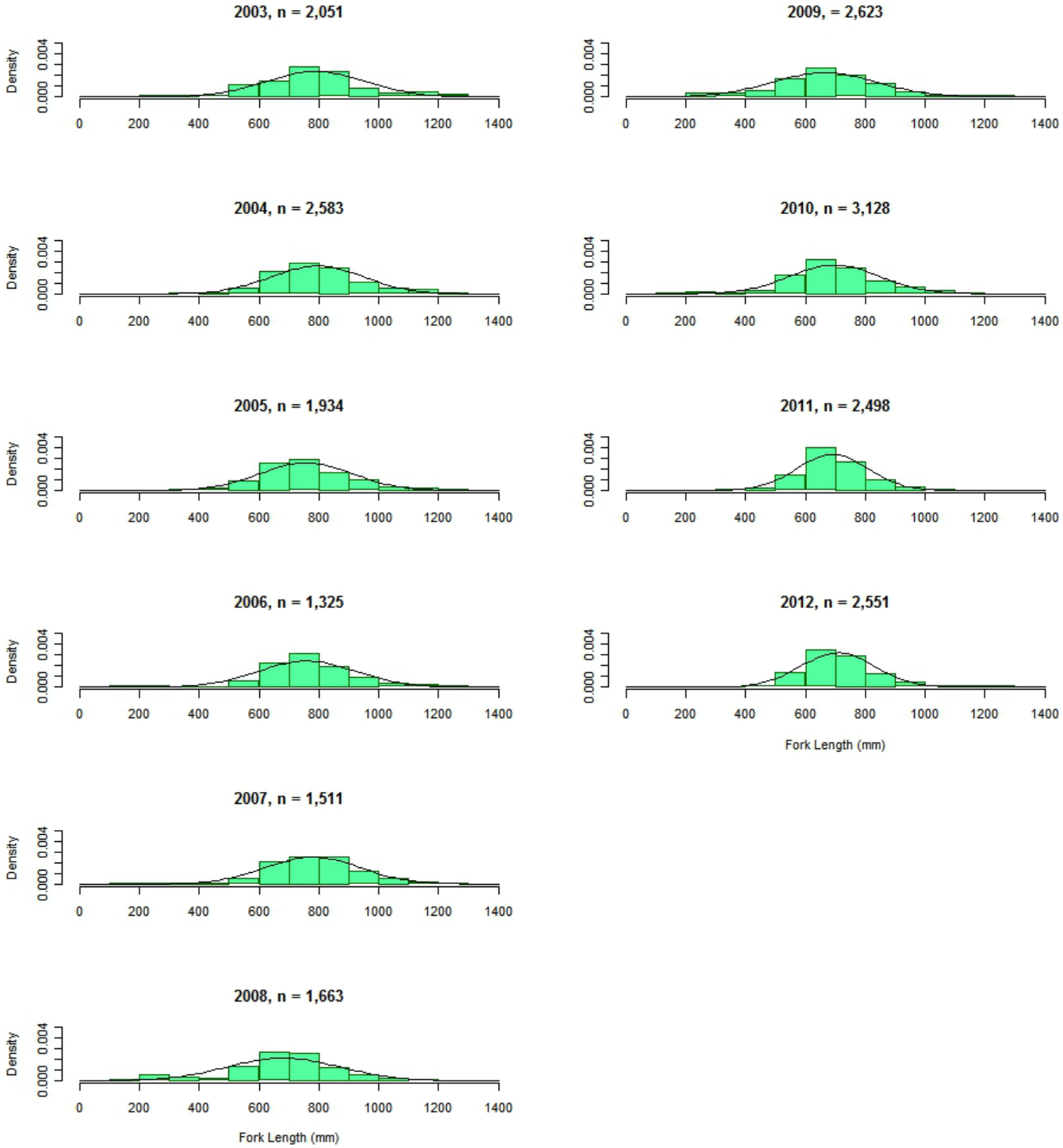


Figure 4. Box plots of (a) fork length and (b) age, which include the median, upper and lower quartiles (boxes: drawn in proportion to the square root of the sample size by year, upper and lower range (dashed line), and outliers (open circles). Vertical lines represent the overall mean (solid line) and upper and lower standard deviations (dashed lines).

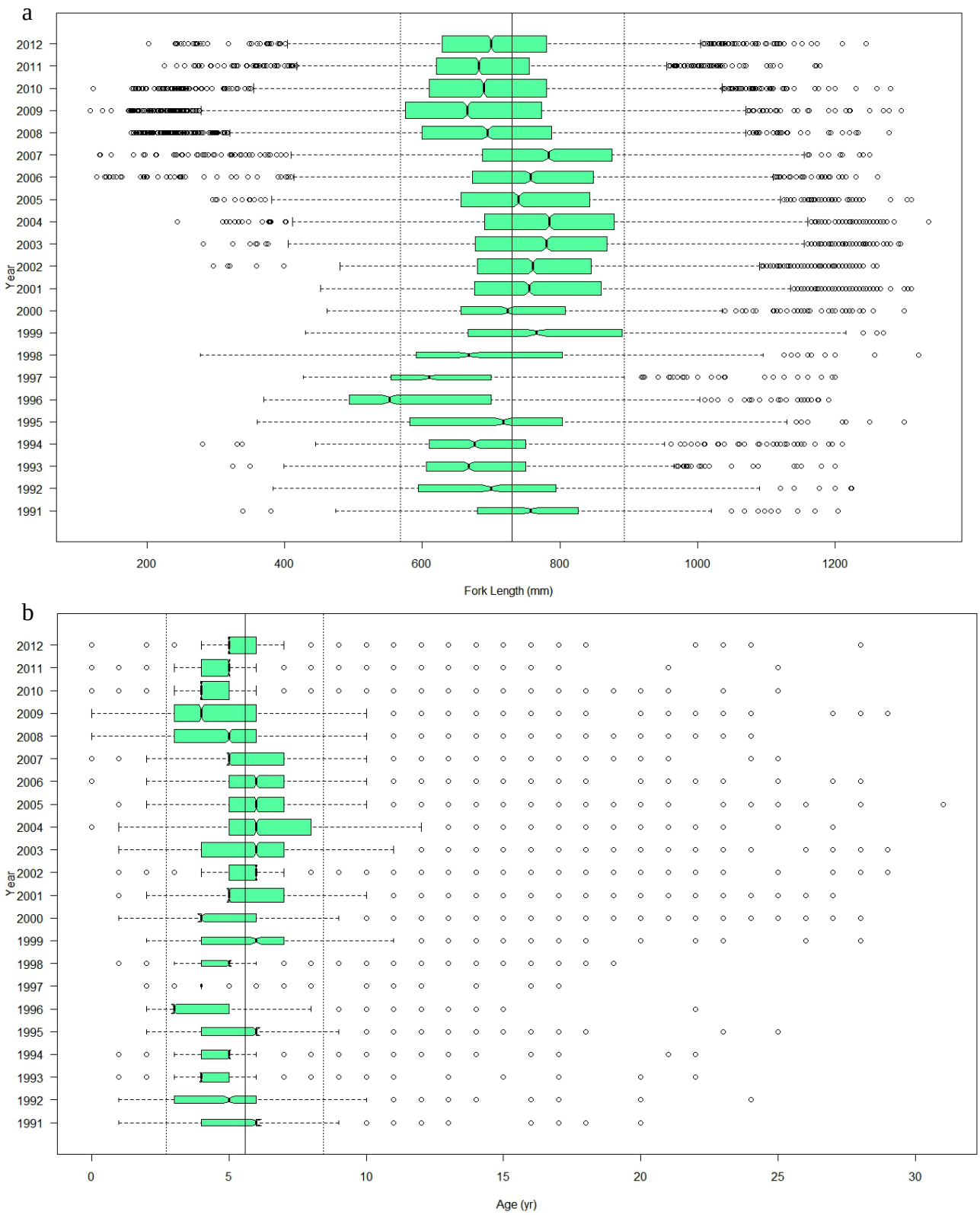


Figure 5. Observed age composition for gag sampled from the northeastern Gulf of Mexico for 1991-2012. Data combined from fishery dependent (commercial and recreational) and independent sources.

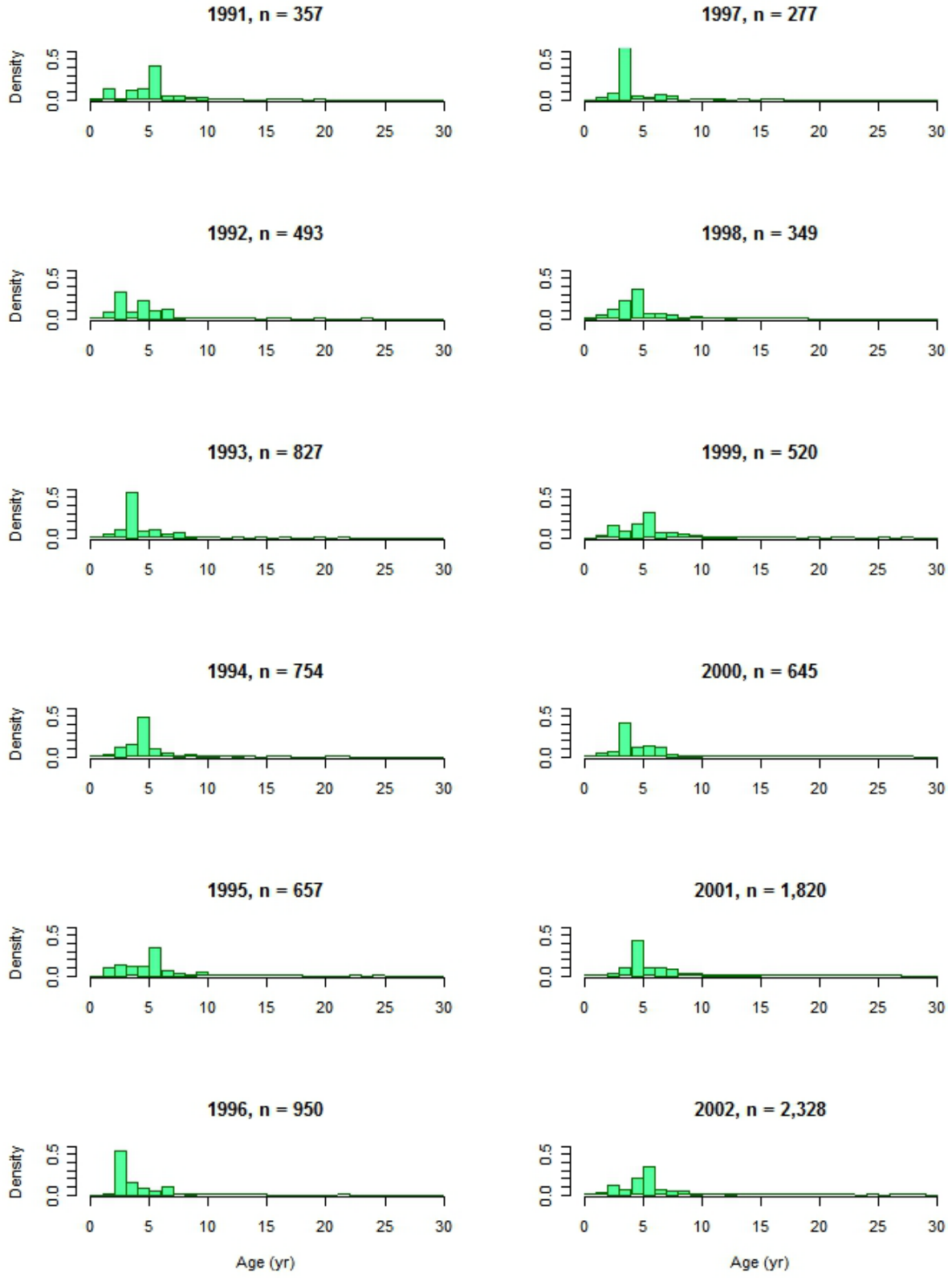


Figure 5. continued

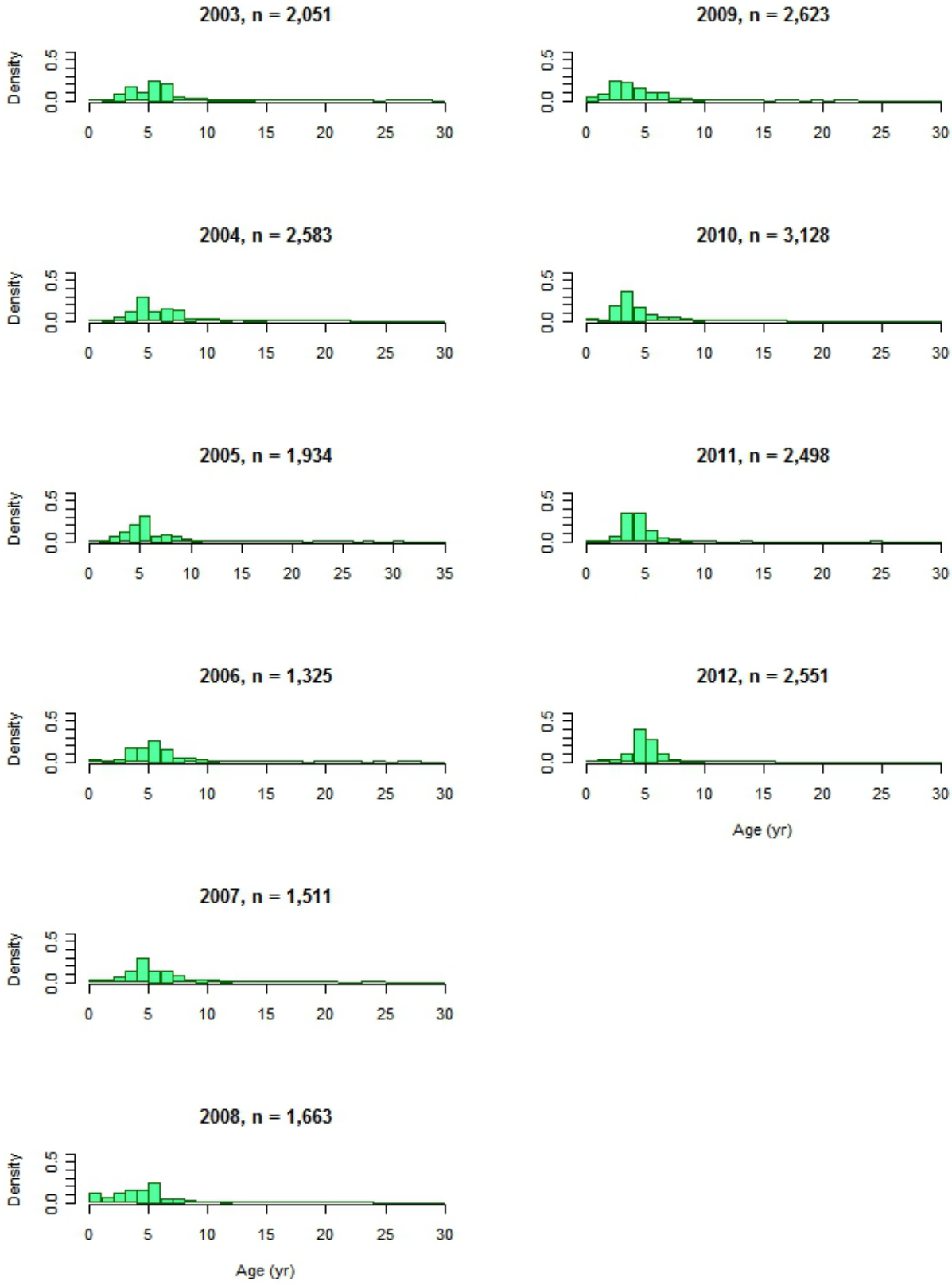


Figure 6. Size-modified von Bertalanffy growth curve for gag from the northeastern Gulf of Mexico for (a) biological ages 0-30 years old and (c) biological ages 0-5 years old. Observed mean size-at-age (black circle), estimated size-at-age (red line), and estimated 95% confidence intervals (red dotted line).