Calculated Goliath grouper discards from commercial vertical line and longline fishing vessels in the Gulf of Mexico and US South Atlantic

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Introduction

In August 2001, the Southeast Fisheries Science Center (SEFSC) initiated a program to collect discard data from commercial fishing vessels landing federally managed species in the Gulf of Mexico and US South Atlantic. A reporting form was developed as a supplement to the mandatory coastal logbook forms for commercial vessels with Federal fishing permits (Poffenberger and McCarthy, 2004). Discard data from the SEFSC coastal fisheries logbook program were used to calculate the number of Goliath grouper that were discarded from commercial fishing vessels during the period January 1, 2002 through December 31, 2009.

Data collection for the discard logbook program involves, each year, a 20% sample of vessels with Federal fishing permits. To assure that the sample was representative of permitted vessels, the universe of those vessels was stratified by region and gear fished. A random sample, weighted by vessel effort reported the previous year, was selected from each stratum. Region was defined as the Gulf of Mexico (Gulf-side of the Florida Keys-Dry Tortugas to the Texas-Mexico border) and the South Atlantic (which extends from the North Carolina-Virginia border to the ocean-side of the Florida Keys-Dry Tortugas). Fishing gear strata included handline, electric reel (bandit rig), trolling, longline, trap, gillnet, and diving. The selected fishers were instructed to complete a supplemental discard form for every fishing trip that they made. Trips with no discards were reported as such.

Reported data included the numbers of discards by species, estimated condition of the fish when released, reason for release (due to regulations or unmarketable/unwanted), and the fishing area where the animal was discarded. There were six options for the condition of released fish: all animals are dead, majority of the animals are dead, all animals are alive when released, majority of animals are alive, the fish are kept but not sold, and the condition of the animals is unknown. To calculate species specific discard rates, discard data were matched to the effort data reported to the coastal logbook program.

Methods

The objective of these analyses was to calculate the numbers of Goliath grouper discarded by commercial vessels that fished for species other than shrimp or other shellfish. Data were restricted to fishing activity reported from vertical line (handlines and electric reels/bandit rigs) and longline gear trips. Reports of Goliath grouper discards were also made for trolling, trap, and diver trips. The available data for those gears were too few for discards to be calculated (22 total trips from those gears).

The data set for these analyses included all trips from vessels that reported discards between January 1, 2002 and December 31, 2009. The data were spatially limited to discards reported from the US South Atlantic off the Florida east coast including the Florida Keys and the eastern Gulf of Mexico off the west coast of Florida, excluding the Panhandle west of Cape San Blas. Data reported from statistical areas within the above region with minimum depths greater than 300 feet were excluded from the analyses.

The data set was also filtered to remove records from fishers that reported "no discards" of any species for 75% or more of reported trips during years with four or more trips reported by the fisher. This data filter was necessary due to consistent non-reporting of discards by some fishers. Including effort from those fishers in calculating discards would result in discard rates that were erroneously low. Fishers may report "no discards" to the discard logbook program and remain in reporting compliance. The percentage of longline trips reported with no discards for the trip has ranged from 20 to 42 percent during 2002-2009. No discards were reported for 25 to 54 percent of vertical line trips (2002-2009). Trips with no discards of any species are rare in the Gulf of Mexico reef fish observer data, suggesting that trips reporting no discards should be much less common than has been found in the self-reported discard logbook data.

The delta lognormal model approach (Lo et al. 1992) was used to calculate the yearly Goliath grouper discard rate. This method combines separate general linear model (GLM) analyses of the proportion of trips that discarded Goliath grouper and the discard rates of trips that discarded Goliath grouper to construct a single standardized discard rate. Total discards for each gear and year combination were then calculated using a ratio estimator: yearly standardized discard rate*reported yearly total effort.

Prior to discard calculation, the data were examined for differences in discard rate and proportion of trips reporting discards. The available data included six factors that were examined for their possible influences on the proportion of longline trips that discarded Goliath grouper and on the discard rate of longline trips. Five factors were tested for their affect on the proportion of vertical line trips that discarded Goliath grouper and on the vertical line discard rate. Discard rate was calculated as the number of Goliath grouper discarded per hook fished (longline) or per hook hour fished (vertical line). Inconsistencies in reporting time fished for longline trips prevented using hook hours as an effort measure for the longline calculations. In order to develop a well balanced sample design, the factors were categorized as:

Longline

Factor	Levels	Value
Year	8	2002-2009
Areas fished (l_region)*	2	Statistical areas 2-4, 5-6; see Figure 1.
Days at sea (seadays)*	3	1-6, 7-10, 11-20
Crew (crew1)*	2	1-2, 3+
Longline length (length)*	3	<4.9, 4.9-6.9, >6.9 miles
Number of hooks fished**	3	<9,601, 9,601-21,000, >21,000

*names in parentheses may appear in some tables or figures
**number of hooks fished was included as a factor in the binomial analysis only

Vertical line

Factor	Levels	Value
Year	8	2002-2009
Areas fished (h_region)*	4	Statistical areas 1-4, 5-7, 2080-2082, 2579-3081; see Figure 1.
Days at sea (seadays)*	2	1, >1
Crew (crew1)*	3	1, 2, 3+
Number of hook hours fished**	3	1-15, 15.1-32, >32

*names in parentheses may appear in some tables or figures
**number of hook hours fished was included as a factor in the binomial analysis only

Generalized linear model (GLM) analyses were used to identify any significant effects the above factors may have had on the Goliath grouper discard rate and proportion of trips reporting Goliath grouper discards. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA). A type3 model

assuming lognormal error distribution was employed. The linking function selected was "normal", and the response variable was log(CPUE) calculated as (longline) log(CPUE) = log(number of Goliath grouper/hook fished) or (vertical line) log(CPUE) = log(number of Goliath grouper/hook hour). For each GLM analysis of proportion of trips reporting Goliath grouper discards, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion Goliath grouper discard trips. Only main effects were examined.

A forward stepwise regression procedure was used to determine the set of fixed factors that explained a significant portion of the observed variability. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ($p<0.05$), and the reduction in deviance per degree of freedom was $\geq 1\%$. This model then became the base model, and the process was repeated, adding factors individually until no factor met the criteria for incorporation into the final model.

The final delta-lognormal model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). The yearly standardized discard rates, calculated for each gear using GLIMMIX, were included in the gear-specific total discards calculation.

A bootstrap resampling technique was used to estimate variability in the calculated total discards. For each year 1,000 data sets were constructed by randomly sampling, with replacement, the original data set used to calculate discard rate. The median, 5th percentile, and 95th percentile yearly discard rates were calculated from the 1,000 bootstrapped data sets. Total discards were calculated for each of those rates to provide a measure of variability associated with the discard calculations.

Discards were calculated for the years 2002-2009 only. Commercial discards were not reported before 2002, except for the final five months of 2001. No effort was made to estimate discards prior to 2002.

Results and Discussion

During this period (2002-2009), discard forms were submitted for 450 longline trips fishing in areas 2-6 in the Gulf of Mexico (total in the filtered data set). There were 11,390 vertical line trips reported to the discard logbook program from the areas included in these analyses. Goliath grouper discards were reported from 89 (0.8%) vertical line and 53 (11.8%) longline trips during 2002-2009. There were 5,804 longline trips in areas 2-6 and 110,096 vertical line trips in the areas included in these analyses that reported to the coastal logbook program during 2002-2009.

The final models for the lognormal on discard rate and binomial on proportion of trips reporting discards were:

Longline:

$$\text{LOG(Discard rate)} = \text{YEAR} + \text{NUMBER of CREW}$$

$$\text{Portion trips reporting discards} = \text{LENGTH of LONGLINE} + \text{YEAR} + \text{HOOKS FISHED} + \text{SEADAYS}$$

Vertical line:

$$\text{LOG(Discard rate)} = \text{SEADAYS} + \text{NUMBER of CREW} + \text{AREA} + \text{YEAR}$$

$$\text{Portion trips reporting discards} = \text{YEAR} + \text{AREA FISHED} + \text{HOOK HOURS FISHED}$$

Calculated total discards for each gear and year (2002-2009) are provided in Tables 1 and 2 for commercial fishing trips deploying longline and vertical line gear, respectively. Calculated discards (those developed using standardized discard rates from the delta-lognormal model) were almost always lower than the median calculated discards estimated from bootstrapping. The proportion of trips reporting Goliath grouper discards was included in the calculation of discard rate when using the delta-lognormal standardization model, accounting for the lower total discards calculated using that method. Coefficients of variation of delta-lognormal calculated discard rates were often high and ranged from 0.45-1.6 for longline discard rates and from 0.31-1.17 for vertical line discard rates.

Vertical line calculated discards (using model generated standardized discard rates) were usually below the 5th percentile of bootstapped total discards. Longline calculated discards were higher than the 5th percentile of bootstrapped total discards. Longline calculated discards were highest during the period 2002-2004 with another, smaller, peak in 2007 (Figure 2). During the 2002-04 period, the highest variability (as defined by the 5th and 95th percentiles of bootstrapped values) was also found. Total discards calculated from vertical line data was less than 1,000 fish per year except for the years 2006-07 and 2009 (Figure 3). Variability in the vertical line calculated discards (as determined by bootstrap estimated discards) was generally consistent among years and did not have the wide range found during the initial years of the longline time series.

The release condition of discarded Goliath grouper is reported in Table 3. There were more than 261 longline and 110 vertical line Goliath grouper discards reported to the coastal logbook discard program. Exact totals could not be provided due to confidentiality restrictions. Overall, 30% of discarded Goliath grouper from longline vessels were reported as "all dead" or "majority dead" and 70% of discards were reported as "all alive" or "majority alive". In some cases, discards were reported by fewer than three vessels and those data could not be included in the table due to confidentiality restrictions. Greater than 95% of vertical line Goliath grouper discards were reported as "all alive" or "majority alive" during each year, 2002-2009. Nearly all Goliath grouper discards were, not surprisingly, reported as "due to regulatory restrictions", except for a small percentage where the reason for discarding the fish was unreported. No estimate of delayed mortality was possible with these data.

The number of trips reporting Goliath grouper discards in the US South Atlantic and Gulf of Mexico was very low. Goliath grouper discards were reported on 15 or more trips during only two years from either longline or vertical line vessels. During six years, five or fewer longline trips reported Goliath grouper discards; however, five or fewer vertical line trips reporting Goliath grouper occurred in only two years. Discard totals, calculated from such relatively rare events, should be used cautiously.

Literature Cited

Lo, N.C., L.D. Jackson, J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

Poffenberger, J. and K. McCarthy. 2004. Estimates of red snapper discards by vessels with Federal permits in the Gulf of Mexico. SEDAR 7-DW-22.

Table 1. Longline trips, total effort (hooks fished), calculated yearly total discards by year. Median, 5th and 95th percentile discards were the discard estimates generated from 1,000 bootstrapped data sets of Goliath grouper longline vessel discard rates. Discards are reported as number of fish.

| Year	Trips	Hooks	Calculated Discards per Hook	Calculated Discards	Median Discards per Hook	Median Calculated Discards	5th Percentile Calculated Discards	95th Percentile Calculated Discards
2002	1,849	24,037,149	0.0000547	1,316	0.00005625	1,352	99	2,975
2003	1,976	29,516,540	0.0000867	2,560	0.00015294	4,514	2,149	8,240
2004	1,904	28,192,645	0.0000286	807	0.00008418	2,373	160	6,365
2005	1,752	22,342,052	0.0000020	45	0.00000212	47	0	136
2006	1,902	25,804,988	0.0000109	280	0.00000933	241	26	617
2007	1,188	20,228,235	0.0000639	1,292	0.00007197	1,456	881	2,138
2008	1,192	18,221,482		0	0.0	0	0	0
2009	1,031	9,868,621	0.0000160	158	0.00001457	144	49	268

Table 2. . Vertical line trips, total effort (hook hours fished), calculated yearly total discards by year. Median, 5th and 95th percentile discards were the discard estimates generated from 1,000 bootstrapped data sets of Goliath grouper vertical line vessel discard rates. Discards are reported as number of fish.

| Year	Trips	Hook Hours	Calculated Discards per Hook Hour	Calculated Discards	Median Discards per Hook Hour	Median Calculated Discards	5th Percentile Calculated Discards	95th Percentile Calculated Discards
2002	23,301	8,555,487	0.0000680	582	0.000155	1,323	989	1,716
2003	23,264	8,284,188	0.0000457	379	0.000164	1,360	1,034	1,761
2004	21,946	7,242,950	0.0000707	512	0.000136	983	493	1,496
2005	18,915	6,288,043	0.0000928	583	0.000317	1,991	1,429	2,602
2006	18,459	6,063,132	0.0005692	3,451	0.001113	6,750	5,682	7,937
2007	17,319	6,443,198	0.0004355	2,806	0.00162	10,435	8,982	11,872
2008	17,025	5,784,396	0.0001347	779	0.000169	976	775	1,195
2009	18,264	6,812,099	0.0002349	1,600	0.000332	2,259	1,697	2,921

Table 3. Percent of Goliath grouper discards by estimated condition at release from commercial hook and line vessels reported by region. Gray cells contain confidential data (reports from fewer than 3 vessels).

Region	Year	All Dead	Majority Dead	All Alive	Majority Alive	Kept	Unknown	Unreported	N Fish
Longline	2002	0.0%	86.4%	9.1%	4.5%	0.0%		0.0%	22
	2003	1.0%	31.3%	40.6%	27.1%	0.0%		0.0%	96
	2004	0.0%	0.0%	41.7%	58.3%	0.0%		0.0%	24
	2005								
	2006	80.0%	0.0%	10.0%	0.0%	0.0%		0.0%	10
	2007	5.2%	21.6%	33.0%	40.2%	0.0%		0.0%	97
	2008	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0
	2009	8.3%	16.7%	0.0%	75.0%	0.0%		0.0%	12
	Total	**5.4%**	**24.2%**	**28.2%**	**41.9%**	**0.0%**		**0.0%**	**261**
Vertical line	2002			90.0%	0.0%	0.0%		0.0%	10
	2003			100.0%	0.0%	0.0%		0.0%	5
	2004								
	2005			100.0%	0.0%	0.0%		0.0%	9
	2006			94.7%	0.0%	0.0%		0.0%	19
	2007			76.7%	23.3%	0.0%		0.0%	30
	2008			90.9%	0.0%	0.0%		0.0%	22
	2009			93.3%	0.0%	0.0%		0.0%	15
	Total			**89.2%**	**6.3%**	**0.0%**		**0.0%**	**110**

Figure 1. Coastal Logbook defined fishing areas with Goliath grouper regions indicated.
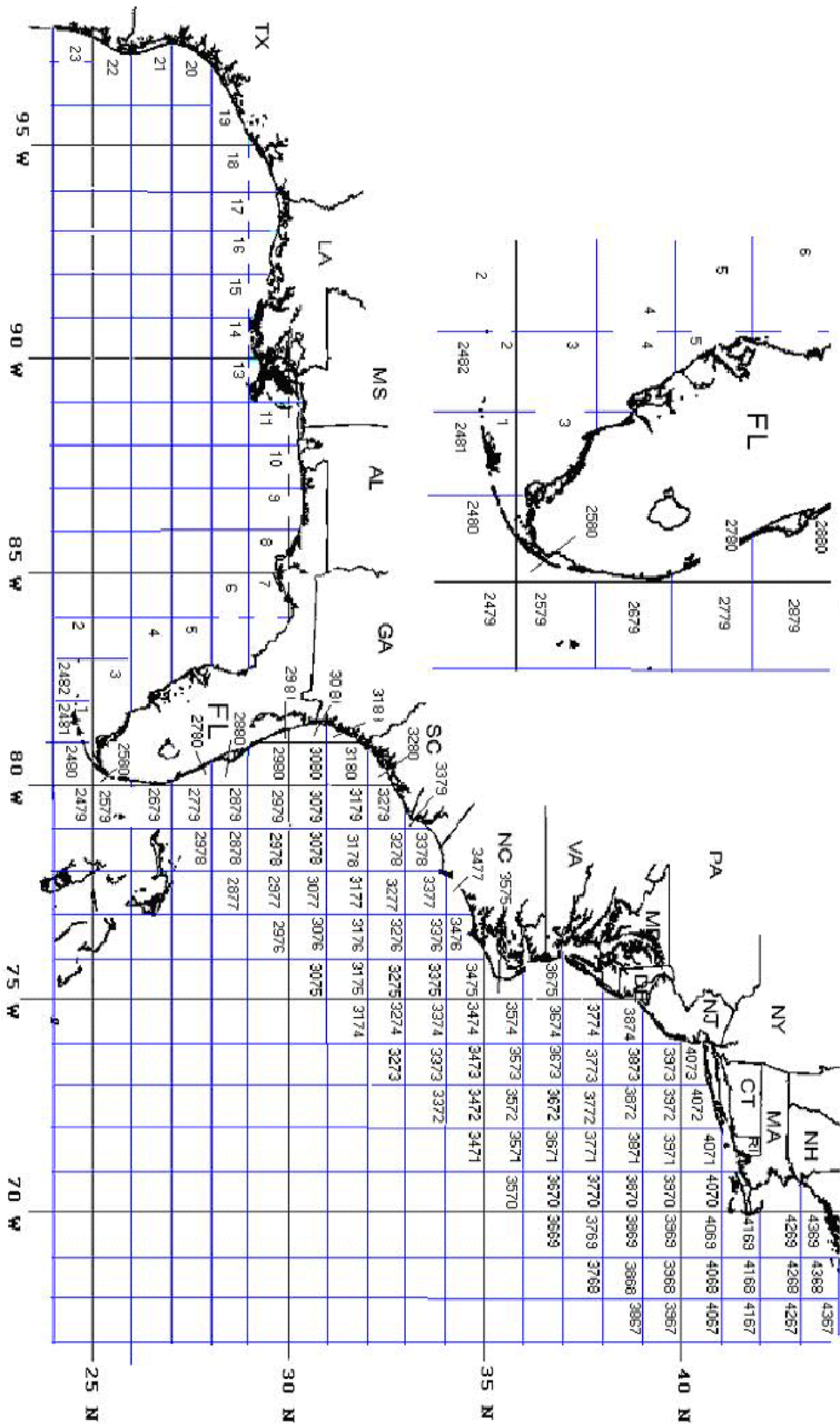
Figure 2. Longline calculated discards from GLIMMIX (delta-lognormal) calculated discard rates. Median, 5th (p5) and 95th (p95) percentile total discards calculated from 1,000 bootstrap resampling iterations.
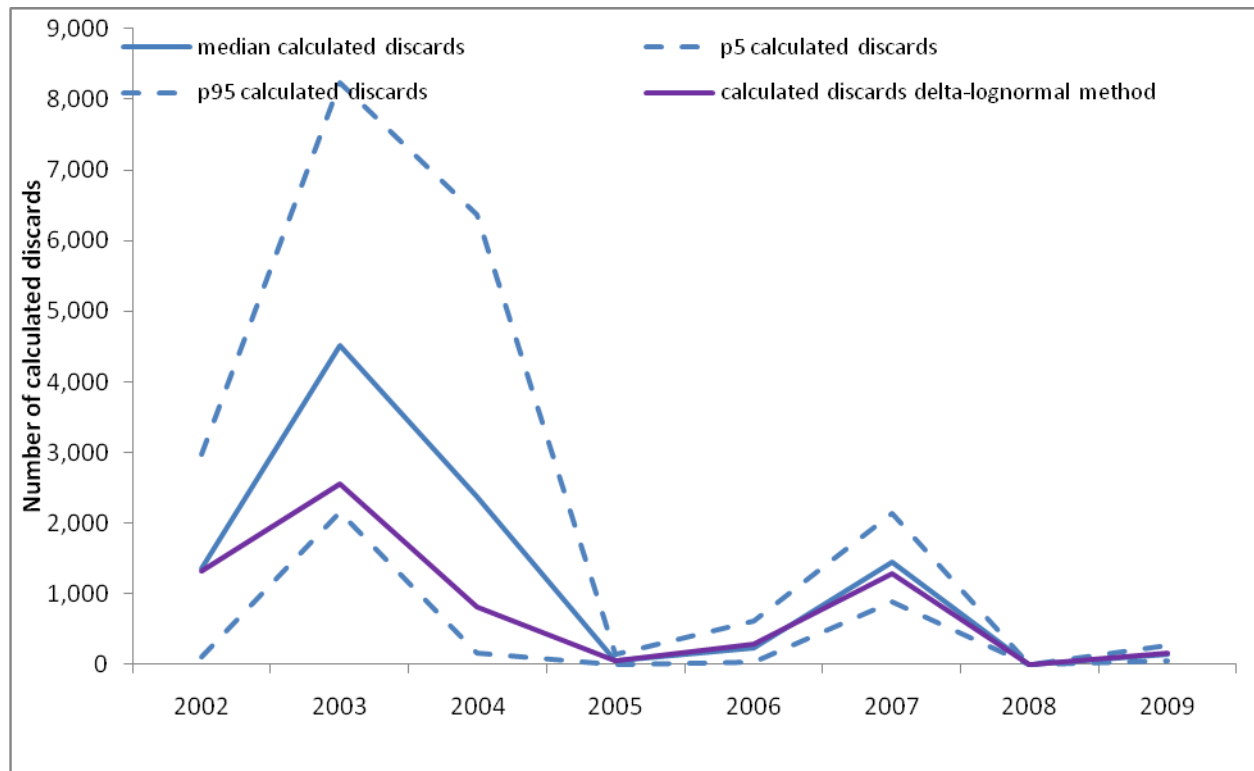
Figure 3. Vertical line calculated discards from GLIMMIX calculated discard rates. Median, 5th (p5) and 95th (p95) percentile total discards calculated from 1,000 bootstrap resampling iterations.