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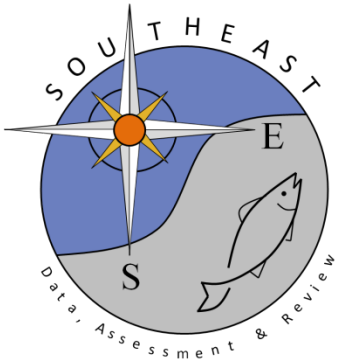

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CPUE Expansion Estimation for Commercial Discards of Gulf of Mexico Scamp & Yellowmouth Grouper

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Abstract

The general approach for estimating discards for the commercial reef fish fleet in the Gulf of Mexico utilizes catch-per-unit-effort (CPUE) from the coastal reef fish observer program and total fishing effort from the commercial reef logbook program to estimate total catch. For discard estimation, CPUE is computed for total discards, including fish released alive, released dead, released in unknown condition, and used for bait. The principal focus of this study was to apply recently developed discard estimation methods for Gulf of Mexico red grouper, gray triggerfish, and vermilion snapper to Gulf of Mexico scamp/yellowmouth grouper. Discard estimation was conducted separately for two gears, vertical line and bottom longline. A verification step compared annual total landed catch from logbook data with the estimated observer annual total landed catch. Once verified, scamp/yellowmouth grouper annual total discards in weight and number were estimated for the observer data period 2007-2018, and then hindcasted for the period 2000-2006. For vertical line gear, estimated discards in number ranged from 3,000 to 4,000 fish during the pre-IFQ management regime 2000-2009, and averaged about 2,500 fish during the IFQ management regime 2010-2018. Discards in weight accounted for about 3% of the total catch (kept + discards) during 2000-2009 and 3.5 to 5% of the total catch during 2010-2018. For bottom longline gear, estimated discards in number averaged about 500 fish for 2000-2018. Discards in weight accounted for about 1 to 1.5% of the total catch (kept + discards) during 2000-2018.

Introduction

The general approach for estimating discards for the commercial reef fish fleet in the Gulf of Mexico utilizes catch-per-unit-effort (CPUE) from the coastal reef fish observer program and total fishing effort from the commercial reef logbook program to estimate total catch,

total Catch = CPUE x total Effort .

For discard estimation, CPUE is computed for total discards, including fish released alive, released dead, released in unknown condition, and used for bait. The primary metric for the coastal observer program is CPUE by species and gear. The principal focus of this study was to apply the discard estimation methods developed for Gulf of Mexico red grouper in SEDAR Working Paper 61-15 (Smith et al. 2018), Gulf of Mexico gray triggerfish in SEDAR Working Paper 62-07 (Smith et al. 2019), and Gulf of Mexico vermilion snapper in SEDAR Working Paper 67-12 (Smith et al. 2019) to Gulf of Mexico scamp and yellowmouth grouper. This application required no additional species-specific modifications to the estimation procedure.

Methods

Data Sources

Catch per unit effort was determined from the coastal reef fish observer program in which scientific observers on commercial fishing vessels recorded detailed information on catch and effort for a subset of trips (Scott-Denton et al. 2011). The program targeted two principal gears for the Gulf of Mexico (GOM) reef fishery, bottom longline and vertical lines (e.g., handlines, electric and hydraulic reels aka bandit reels). Catch by species was recorded according to disposition category: kept (landed), released alive, released dead, released undetermined, and used for bait. Length and weight were recorded for a subsample of individual fish. The coastal reef fish observer program began in July 2006; for GOM scamp/yellowmouth grouper discard estimation, complete calendars years 2007-2018 were used. Time periods for the methodology can be defined in terms of the observer program, with the pre-observer time period representing years prior to 2007, and the observer time period representing years 2007 and beyond.

Total effort was determined from the commercial coastal logbook program in which fishers reported basic information on effort and catch by species for every trip. The reef logbook program began in 1990 for a subset of vessels in the GOM, and expanded to all vessels in 1993; for GOM scamp/yellowmouth grouper discard estimation, complete calendar years 1993-2018 were considered.

Relevant Management History of GOM Scamp/Yellowmouth Grouper

There were two key management changes relevant to discard estimation: (1) The establishment of a minimum size in late 1999 (16” TL); and (2) the implementation in 2010 of an Individual Fisheries Quota for the GOM shallow-water grouper aggregate comprised of four species—black grouper, scamp, yellowmouth grouper, yellowfin grouper. Two management regimes were defined, the pre-IFQ period (prior to 2010) and the IFQ period (2010 and later).

Species

Per recommendation of the stock assessment analysts, data were combined for scamp and yellowmouth grouper.

Gear

In the coastal observer data, scamp and yellowmouth grouper were observed on both vertical line and bottom longline trips. Discard estimation was conducted separately for the two gears.

Trip-Level Catch for Observer Data

Observers collected catch data at a sub-trip level (e.g., a specific set and line for vertical line gear), but it was not feasible to sample every set, line, etc., for every trip. Gear-specific procedures were applied to estimate the trip-level landed catch from the observer data (Smith et al. 2018).

Trip-Level Effort for Observer and Logbook Data

For observer data, trip-level effort for vertical lines was computed as the cumulative daily fishing time (hours) from first hook in to last hook out; this time metric included the active fishing time as well as transit time between fishing locations during a given trip day. This effort variable generally matched trip fishing time reported in vessel logbook data (Smith et al. 2018). For bottom longlines, trip-level effort was the number of sets fished; this effort variable matched the number of sets reported in vessel logbook data (Smith et al. 2018).

Catch Expansion Procedures and Verification

Observer CPUE was calculated using trip-level nominal effort and catch for a given time period. Statistical estimation of total catch $\hat{C}$ and associated variance followed procedures for a (Horvitz-Thompson) survey design ratio estimator (Jones et al. 1995; Lohr 2010):

$$\hat{C} = \overline{CPUE} \times \hat{X} \quad ,$$

where $\overline{CPUE}$ is observer mean CPUE and $\hat{X}$ is total logbook nominal effort. Species- and gear-specific logbook total effort $\hat{X}$ was calculated in two steps. First, logbook trip effort by gear was summed over trips reporting landings of the target species. Second, to obtain $\hat{X}$, logbook trip effort was adjusted by the proportion of observer trip effort that reported only discards of the target species. Logbook total trips *N* were calculated in a similar manner.

Mean CPUE was estimated by

$$\overline{CPUE} = \frac{\bar{y}}{\bar{x}} \quad ,$$

where $\bar{y}$ is average catch per trip *i*,

$$\bar{y} = \frac{1}{n}\sum_i y_i \quad ,$$

$\bar{x}$ is average effort per trip *i*,

$$\bar{x} = \frac{1}{n}\sum_i x_i \quad ,$$

and *n* is the number of observer trips. Variance of total catch was estimated using

$$var\left[\hat{C}\right] = \left(1 - \frac{n}{N}\right)\left(\frac{\hat{X}}{\bar{x}}\right)^2 \frac{s^2(y|x)}{n} \quad ,$$

where *N* is the total number of logbook trips and sample variance is

$$s^2(y|x) = \frac{\sum_i (y_i - \overline{CPUE}x_i)^2}{n-1} \quad .$$

Variance of $\hat{C}$ was estimated using

$$var\left[\hat{C}\right] = var[\overline{CPUE}] \times \hat{X}^2 \quad .$$

Standard error of total catch was calculated as

$$SE\left[\hat{C}\right] = \sqrt{var\left[\hat{C}\right]} \quad .$$

The CV of total catch $\hat{C}$ was estimated by

$$CV\left[\hat{C}\right] = \frac{SE[\hat{C}]}{\hat{C}} \quad .$$

A verification step compared annual total landed catch from logbook data with the estimated observer annual total catch $\hat{C}$. Once verified, the catch expansion procedure was used to estimate annual total discards in weight and number.

Spatial Domain

Per recommendation of the stock assessment analysts, discard estimates were conducted for the GOM, defined as statistical zones 1-21 (**Fig. 1**).

Hindcast Procedures

For years prior to 2007, before observer data were collected, hindcast discard estimation procedures for "Trending CPUE" described in Smith et al. (2019a) were applied to scamp/yellowmouth grouper. For this method, the ratio of observer CPUE in weight to logbook CPUE was computed for the observer time period, and then multiplied by the annual logbook CPUE for the hindcast time period to produce an estimated annual observer CPUE. Then, the annual observer CPUE was multiplied by annual logbook effort for the pre-observer time period to estimate total catch $\hat{C}$ in weight. An additional step computed the ratio of the observer CPUE in number to observer CPUE in weight. This ratio was then used to compute the observer estimated discards in number from the discards in weight for the hindcast period. Standard errors for the hindcast period were estimated using the respective CVs of total estimated catch $\hat{C}$ kept and discarded as described in Smith et al. (2019a). To guide selection of appropriate time periods for hindcasting, time-series of annual length compositions for kept and discarded fish from observer sampling were evaluated with respect to pre-IFQ (2007-2009) and IFQ (2010-

2018) management regimes. Verification compared total landed catch from logbook data with the estimated total catch $\hat{C}$ and standard error from observer data for the hindcast time period.

Results and Discussion

Vertical Line

The observer database included 1,058 vertical line trips with corresponding trip and set information. Observer sampling effort is summarized in **Table 1**, distinguishing all trips from the subset of trips that captured scamp/yellowmouth grouper.

For the pre-IFQ period 2007-2009, the disposition (kept or discarded) of GOM scamp/yellowmouth grouper corresponded with the minimum size limit of 16" TL (377 mm FL) (**Fig. 2**). Discards were mostly fish near or below the minimum size limit, and kept fish were mostly above the minimum size limit. For the IFQ period, 2010-2018, discards included fish below and above the minimum size limit. In addition, legal-sized fish were discarded on some of the same trips that kept legal-sized fish. Discard estimation was conducted separately within the pre-IFQ (2007-2009) and IFQ (2010-2018) management regimes to account for potential changes in the discard CPUE indicated by differences in the discard length frequencies.

Observer data from the pre-IFQ period (2007-2009) were used for hindcasting discards for the pre-observer years 2000-2006, which had the same minimum size limit (16" TL). Hindcasting for years prior to 2000 when there was no size limit in effect was not possible, given the lack of data on discard length frequencies for that time period (1993-1999).

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting scamp/yellowmouth grouper showed a fairly stable trend within the pre-IFQ management regime, followed by a general decrease in the average CPUE and more year-to-year fluctuations in the IFQ management regime (**Fig. 3**). Catch-effort data for observer trips catching scamp/yellowmouth grouper were pooled across years for the respective management regimes. Logbook catch-effort data for scamp/yellowmouth grouper trips were pooled in the same manner. These observer and logbook datasets were the basis for subsequent analysis and estimation of catch and discards for the pre-IFQ and IFQ management regimes.

Observer and logbook frequency distributions of trip-level catch, effort, and CPUE were similar for IFQ management regime (2010-2018), suggesting that observer sampling of scamp/yellowmouth grouper trips was representative of the commercial fleet. This was not the case for years 2007-2009 (pre-IFQ management regime). Further analysis showed that observers sampled a higher proportion of moderate catch (15-40 lbs.) scamp/yellowmouth grouper trips and a lower proportion of low (<15 lbs.) and high catch (>40 lbs) trips relative to the commercial fleet (**Table 2**). To account for this discrepancy, observer and logbook trips were grouped into strata according to low (L), moderate (M), and high (H) catches for subsequent analysis and estimation.

The proportions of observer trips and effort encountering scamp/yellowmouth grouper that had kept fish are given in **Table 3** by management regime and catch level strata. These proportions were used to adjust annual logbook total scamp/yellowmouth grouper trips and effort (**Table 4**) to account for logbook trips that only had discarded fish. Estimates of observer mean CPUE by management regime and catch level strata are given in **Table 5.** These CPUEs were the basis for expansion estimates of scamp/yellowmouth grouper catch and discards. Observer

discard CPUEs for the pre-IFQ management regime (2007-2009) were the basis for hindcasting discards during 2000-2006.

CPUE expansion estimates of annual total landed catch of GOM scamp/yellowmouth grouper compared favorably with reported logbook landings for 2000-2018 (**Fig. 4**). CPUE expansion estimates for annual discards in numbers and weight of GOM scamp/yellowmouth grouper for 2000-2018 are provided in **Table 6**. Estimated discards in number ranged from 3,000 to 4,000 fish during the pre-IFQ management regime 2000-2009, and averaged about 2,500 fish during the IFQ management regime 2010-2018 (**Fig. 5A**). Discards in weight accounted for about 3% of the total catch (kept + discards) during 2000-2009 and 3.5 to 5% of the total catch during 2010-2018 (**Fig. 5B**).

Bottom Longline

The observer database included 401 bottom longline trips with corresponding trip and set information. Observer sampling effort is summarized in **Table 7**, distinguishing all trips from the subset of trips that captured scamp/yellowmouth grouper.

For the pre-IFQ period 2007-2009, the disposition (kept or discarded) of GOM scamp/yellowmouth grouper corresponded with the minimum size limit of 16" TL (377 mm FL) (**Fig. 6**). Discards were mostly fish near or below the minimum size limit, and kept fish were mostly above the minimum size limit. For the IFQ period, 2010-2018, discards included fish below and above the minimum size limit. In addition, legal-sized fish were discarded on some of the same trips that kept legal-sized fish. Discard estimation was conducted separately within the pre-IFQ (2007-2009) and IFQ (2010-2018) management regimes to account for potential changes in the discard CPUE indicated by differences in the discard length frequencies.

Observer data from the pre-IFQ period (2007-2009) were used for hindcasting discards for the pre-observer years 2000-2006, which had the same minimum size limit (16" TL). Hindcasting for years prior to 2000 when there was no size limit in effect was not possible, given the lack of data on discard length frequencies for that time period (1993-1999).

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting scamp/yellowmouth grouper showed a general increase in CPUE during the pre-IFQ management regime, followed by a general decrease during the IFQ management regime (**Fig. 7**). Catch-effort data for observer trips catching scamp/yellowmouth grouper were pooled across years for the respective management regimes. Logbook catch-effort data for scamp/yellowmouth grouper trips were pooled in the same manner. These observer and logbook datasets were the basis for subsequent analysis and estimation of catch and discards for the pre-IFQ and IFQ management regimes.

Observer and logbook frequency distributions of trip-level catch, effort, and CPUE were similar for IFQ management regime (2010-2018), suggesting that observer sampling of scamp/yellowmouth grouper trips was representative of the commercial fleet. This was not the case for years 2007-2009 (pre-IFQ management regime). Further analysis showed that observers sampled a higher proportion of low catch (<74 lbs.) scamp/yellowmouth grouper trips and a lower proportion of high catch (>74 lbs) trips relative to the commercial fleet (**Table 8**). To account for this discrepancy, observer and logbook trips were grouped into strata according to low (L) and high (H) catches for subsequent analysis and estimation.

The proportions of observer trips and effort encountering scamp/yellowmouth grouper that had kept fish are given in **Table 9** by management regime and catch level strata. These proportions were used to adjust annual logbook total scamp/yellowmouth grouper trips and effort (**Table 10**) to account for logbook trips that only had discarded fish. Estimates of observer mean CPUE by management regime and catch level strata are given in **Table 11.** These CPUEs were the basis for expansion estimates of scamp/yellowmouth grouper catch and discards. Observer discard CPUEs for the pre-IFQ management regime (2007-2009) were the basis for hindcasting discards during 2000-2006.

CPUE expansion estimates of annual total landed catch of GOM scamp/yellowmouth grouper compared favorably with reported logbook landings for 2000-2018 (**Fig. 8**). CPUE expansion estimates for annual discards in numbers and weight of GOM scamp/yellowmouth grouper for 2000-2018 are provided in **Table 12**. Estimated discards in number averaged about 500 fish for 2000-2018 (**Fig. 9A**). Discards in weight accounted for about 1 to 1.5% of the total catch (kept + discards) during 2000-2018 (**Fig. 9B**).

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Table 1. Number of total and Scamp/Yellowmouth Grouper coastal observer vertical line trips by year for the GOM.

Year	Total Trips	Scamp/Yellowmouth Grouper Trips
2007	73	48
2008	37	25
2009	36	18
2010	48	20
2011	90	37
2012	213	125
2013	112	42
2014	89	46
2015	162	70
2016	113	51
2017	55	22
2018	30	17

Table 2. Definition of trip catch level strata for GOM Scamp and Yellowmouth Grouper, and corresponding percentages of logbook and observer vertical line trips during the pre-IFQ period 2007-2009.

Trip Catch Level	Stratum Code	% Trips	
		Logbook	Observer
Low, catch ≤ 15 lbs.	L	24.8	19.0
Moderate, 15 < catch ≤ 40 lbs.	M	27.5	44.3
High, catch > 40 lbs.	H	47.7	36.7

Table 3. Scamp/YMG vertical line effort and catch adjustment factors by management regime and catch level strata in GOM. Catch level strata for pre-IFQ management regime are defined in Table 2; catch level stratum 'A' is all levels (i.e., no stratification) for the IFQ management regime. The proportions of Scamp/YMG observer trips and effort with kept Scamp and Yellowmouth Grouper were used to respectively adjust annual logbook total trips and effort (Table 4) to account for logbook trips that only had discarded fish.

Management Regime	Catch Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Vermilion Snapper	
			Trips	Effort
Pre-IFQ, 2007-2009	L	47	0.7447	0.8488
	M	15	1.0	1.0
	H	29	1.0	1.0
IFQ, 2010-2018	A	430	0.8535	0.9081

Table 4. Annual time-series of vertical line logbook trips (number) and effort (hours) by catch level strata for GOM Scamp and Yellowmouth Grouper.

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted $(\hat{X})$
2000	L	713	957	24,707	29,108
	M	568	568	24,342	24,342
	H	858	858	51,187	51,187
2001	L	643	863	22,615	26,643
	M	610	610	27,403	27,403
	H	1,102	1,102	61,395	61,395
2002	L	759	1,019	24,698	29,097
	M	768	768	31,871	31,871
	H	1,190	1,190	66,538	66,538
2003	L	942	1,265	31,447	37,048
	M	818	818	36,251	36,251
	H	1,302	1,302	73,080	73,080
2004	L	885	1,188	28,612	33,708
	M	772	772	32,066	32,066
	H	1,246	1,246	67,639	67,639
2005	L	595	799	20,515	24,168
	M	615	615	26,076	26,076
	H	1,193	1,193	65,643	65,643
2006	L	684	919	25,550	30,101
	M	623	623	29,410	29,410
	H	977	977	56,271	56,271
2007	L	918	918	62,538	62,538
	M	527	708	24,142	28,442
	H	486	486	25,603	25,603
2008	L	859	859	53,220	53,220
	M	538	722	24,728	29,132
	H	470	470	23,773	23,773
2009	L	1,055	1,055	69,180	69,180
	M	562	755	26,799	31,572
	H	518	518	26,234	26,234
2010	A	1,410	1,652	82,664	91,026
2011	A	1,632	1,912	93,391	102,838
2012	A	2,049	2,401	116,849	128,669
2013	A	1,674	1,961	96,328	106,073
2014	A	1,664	1,950	90,705	99,881
2015	A	1,528	1,790	78,575	86,524
2016	A	1,822	2,135	95,254	104,890
2017	A	1,429	1,674	72,105	79,399
2018	A	1,353	1,585	62,242	68,538

Table 5. Estimated observer mean CPUE in weight and numbers by management regime and catch level strata for expansion estimates of vertical line GOM Scamp/Yellowmouth Grouper catch and discards.

Management Regime	Catch Level	Observer CPUE, pounds per hour		Observer CPUE, numbers per hour	
		Kept	Discard	Kept	Discard
pre-IFQ, 2007-2009	L	0.1402	0.0236	0.0490	0.0154
	M	0.5095	0.0340	0.1492	0.0254
	H	1.8895	0.0423	0.4375	0.0318
IFQ, 2010-2018	A	0.9749	0.0430	0.2085	0.0266

Table 6. Time-series of CPUE expansion estimates for GOM Scamp & Yellowmouth Grouper vertical line discards in weight (lbs.) and number (with associated standard errors).

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2000	4,035.2	1,556.7	2,946.0	1,149.4
2001	4,727.3	1,823.7	3,469.9	1,353.9
2002	5,239.0	2,021.1	3,842.2	1,499.1
2003	5,790.0	2,233.7	4,235.7	1,652.6
2004	5,582.6	2,153.7	4,083.2	1,593.1
2005	4,913.5	1,895.5	3,611.2	1,409.0
2006	4,416.5	1,703.8	3,230.8	1,260.6
2007	4,186.5	1,615.0	3,080.2	1,201.8
2008	3,746.5	1,490.8	2,747.8	1,113.3
2009	4,562.8	1,833.7	3,356.1	1,382.2
2010	3,910.7	2,175.9	2,421.5	1,019.3
2011	4,418.2	2,458.3	2,735.7	1,151.5
2012	5,528.0	3,075.8	3,422.9	1,440.8
2013	4,557.2	2,535.6	2,821.7	1,187.8
2014	4,291.1	2,387.6	2,657.0	1,118.4
2015	3,717.3	2,068.3	2,301.7	968.9
2016	4,506.3	2,507.3	2,790.3	1,174.5
2017	3,411.2	1,898.0	2,112.2	889.1
2018	2,944.6	1,638.4	1,823.3	767.5

Table 7. Number of total and Scamp/Yellowmouth Grouper coastal observer bottom longline trips by year for the GOM.

Year	Total Trips	Scamp/Yellowmouth Grouper Trips
2007	10	6
2008	5	2
2009	32	24
2010	51	37
2011	78	58
2012	19	12
2013	81	59
2014	27	22
2015	26	20
2016	55	44
2017	13	11
2018	4	4

Table 8. Definition of trip catch level strata for GOM Scamp and Yellowmouth Grouper, and corresponding percentages of logbook and observer bottom longline trips during the pre-IFQ period 2007-2009.

Trip Catch Level	Stratum Code	% Trips	
		Logbook	Observer
Low, catch ≤ 74 lbs.	L	45.8	58.1
High, catch > 74 lbs.	H	54.2	41.9

Table 9. Scamp/YMG bottom longline effort and catch adjustment factors by management regime and catch level strata in GOM. Catch level strata for pre-IFQ management regime are defined in Table 8; catch level stratum 'A' is all levels (i.e., no stratification) for the IFQ management regime. The proportions of Scamp/YMG observer trips and effort with kept Scamp and Yellowmouth Grouper were used to respectively adjust annual logbook total trips and effort (Table 10) to account for logbook trips that only had discarded fish.

Management Regime	Catch Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Vermilion Snapper	
			Trips	Effort
Pre-IFQ, 2007-2009	L	19	0.9474	0.9648
	H	13	1.0	1.0
IFQ, 2010-2018	A	267	0.9888	0.9874

Table 10. Annual time-series of bottom longline logbook trips (number) and effort (sets) by catch level strata for GOM Scamp and Yellowmouth Grouper.

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (*N*)	Reported	Adjusted $(\hat{X})$
2000	L	377	398	9,986	10,350
	H	292	292	9,389	9,389
2001	L	383	404	9,833	10,192
	H	348	348	11,422	11,422
2002	L	382	403	9,741	10,096
	H	335	335	10,131	10,131
2003	L	474	500	11,158	11,565
	H	385	385	10,971	10,971
2004	L	442	467	8,805	9,126
	H	424	424	11,348	11,348
2005	L	370	391	6,994	7,249
	H	482	482	10,214	10,214
2006	L	452	477	8,924	9,249
	H	328	328	6,860	6,860
2007	L	288	304	6,187	6,412
	H	314	314	7,466	7,466
2008	L	329	347	7,286	7,552
	H	400	400	9,412	9,412
2009	L	178	188	4,150	4,301
	H	228	228	6,238	6,238
2010	A	271	274	7,614	7,711
2011	A	414	419	12,262	12,419
2012	A	435	440	11,526	11,674
2013	A	474	479	13,912	14,090
2014	A	471	476	15,924	16,128
2015	A	520	526	18,785	19,026
2016	A	574	581	20,173	20,431
2017	A	528	534	19,565	19,816
2018	A	467	472	17,172	17,392

Table 11. Estimated observer mean CPUE in weight and numbers by management regime and catch level strata for expansion estimates of bottom longline GOM Scamp/Yellowmouth Grouper catch and discards.

Management Regime	Catch Level	Observer CPUE, pounds per hour		Observer CPUE, numbers per hour	
		Kept	Discard	Kept	Discard
pre-IFQ, 2007-2009	L	1.4013	0.0339	0.2648	0.0177
	H	11.9721	0.1742	2.1415	0.0567
IFQ, 2010-2018	A	6.2463	0.0598	1.2100	0.0325

Table 12. Time-series of CPUE expansion estimates for GOM Scamp & Yellowmouth Grouper bottom longline discards in weight (lbs.) and number (with associated standard errors).

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2000	1,237.0	773.0	461.9	229.5
2001	1,547.5	967.1	564.2	280.3
2002	1,453.6	908.4	532.8	264.7
2003	1,728.2	1,080.0	643.1	319.5
2004	1,900.6	1,187.7	688.0	341.8
2005	1,925.4	1,203.2	691.9	343.8
2006	1,354.6	846.5	510.0	253.4
2007	1,518.0	948.6	536.8	266.7
2008	1,895.6	1,184.6	667.3	331.6
2009	1,232.5	770.2	429.8	213.6
2010	460.8	180.8	250.5	83.3
2011	742.1	291.2	403.4	134.2
2012	697.6	273.7	379.2	126.1
2013	842.0	330.4	457.7	152.2
2014	963.7	378.1	523.9	174.3
2015	1,136.9	446.1	618.1	205.6
2016	1,220.9	479.0	663.7	220.8
2017	1,184.1	464.6	643.7	214.1
2018	1,039.3	407.8	565.0	187.9

Figure 1. Map of sampling areas in the Gulf of Mexico (map provided by B. Wrege).

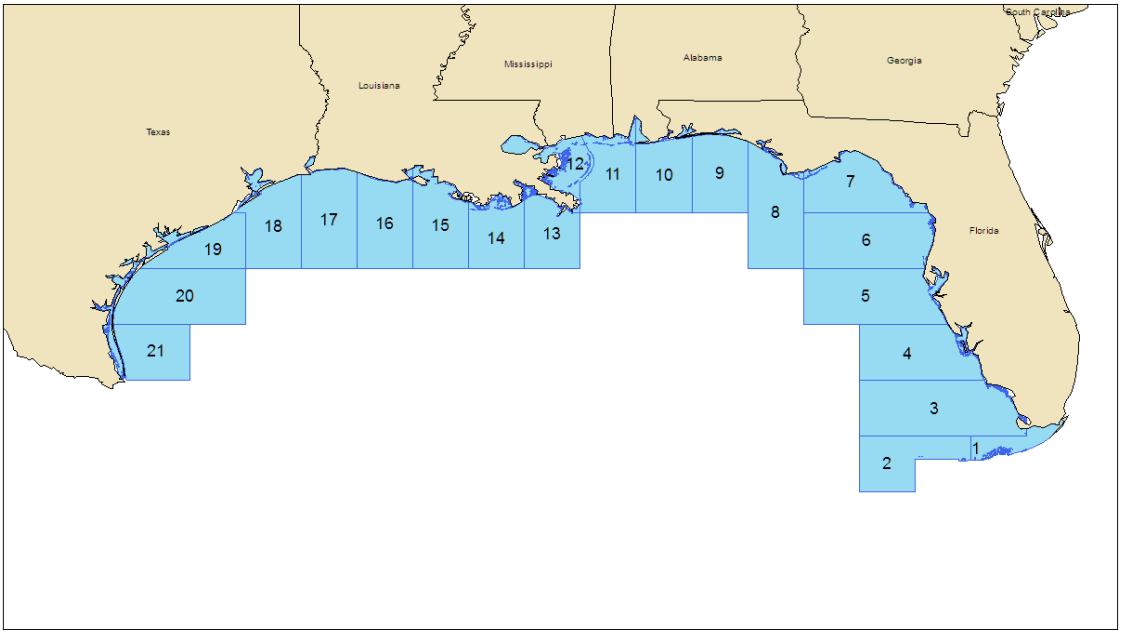
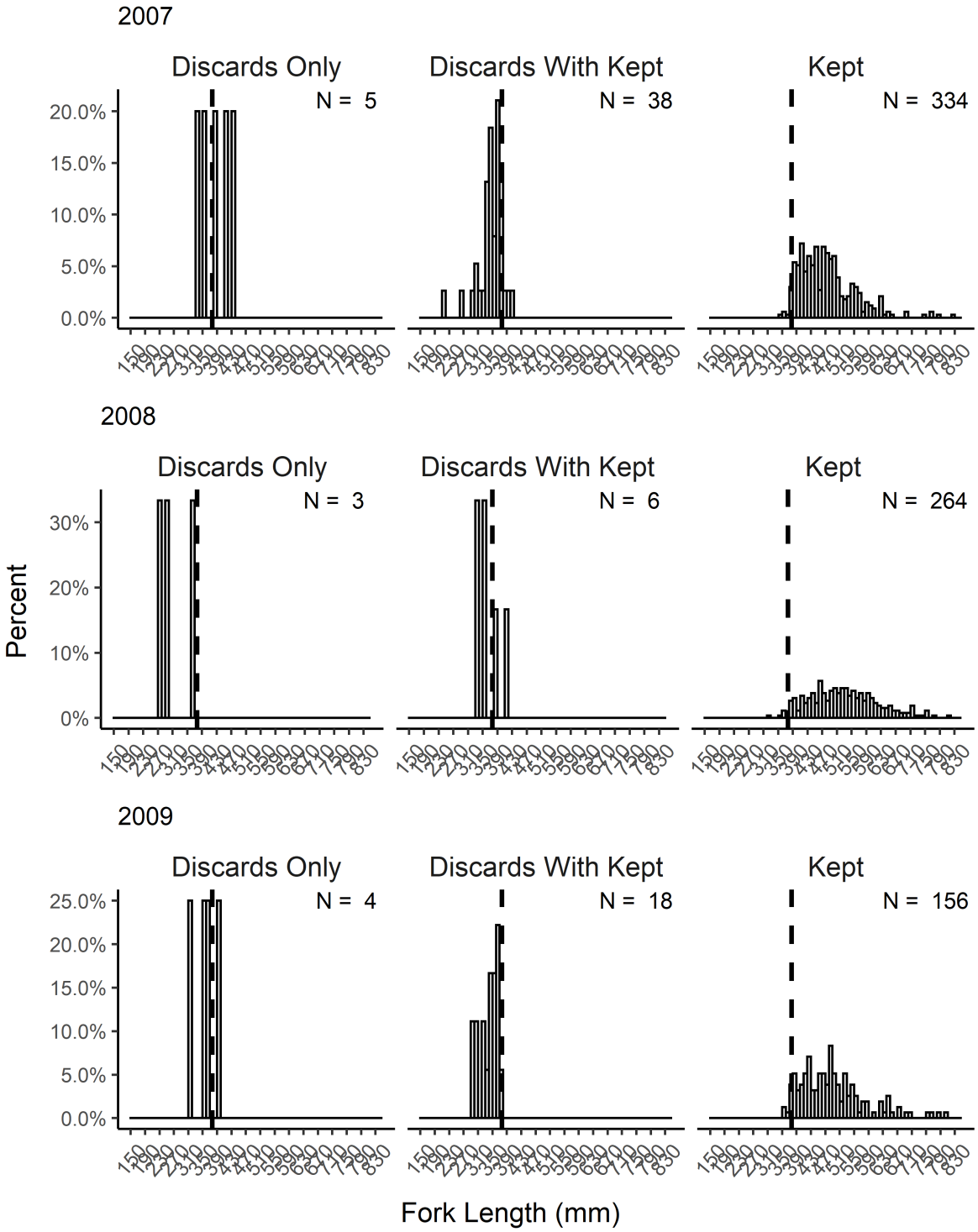
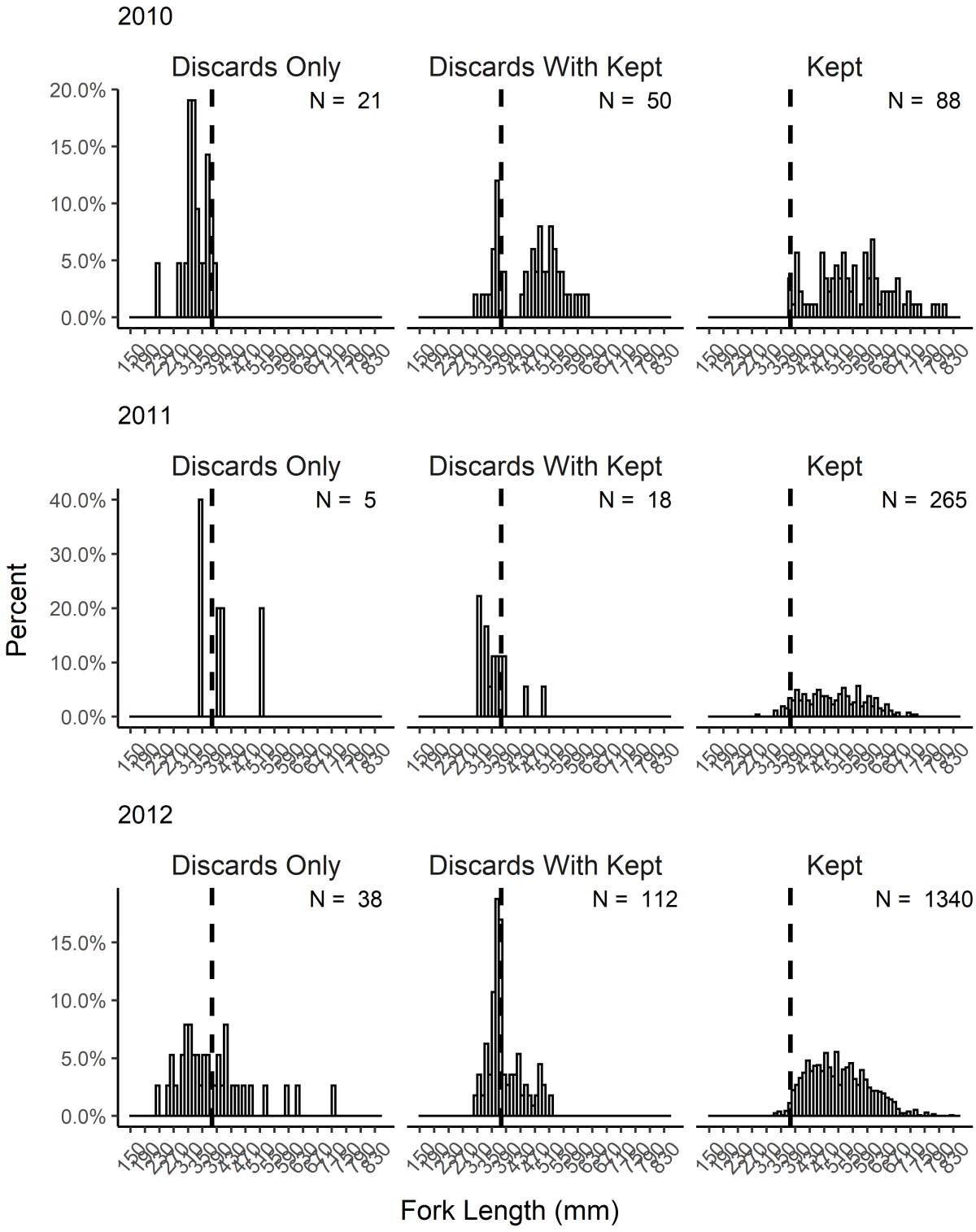
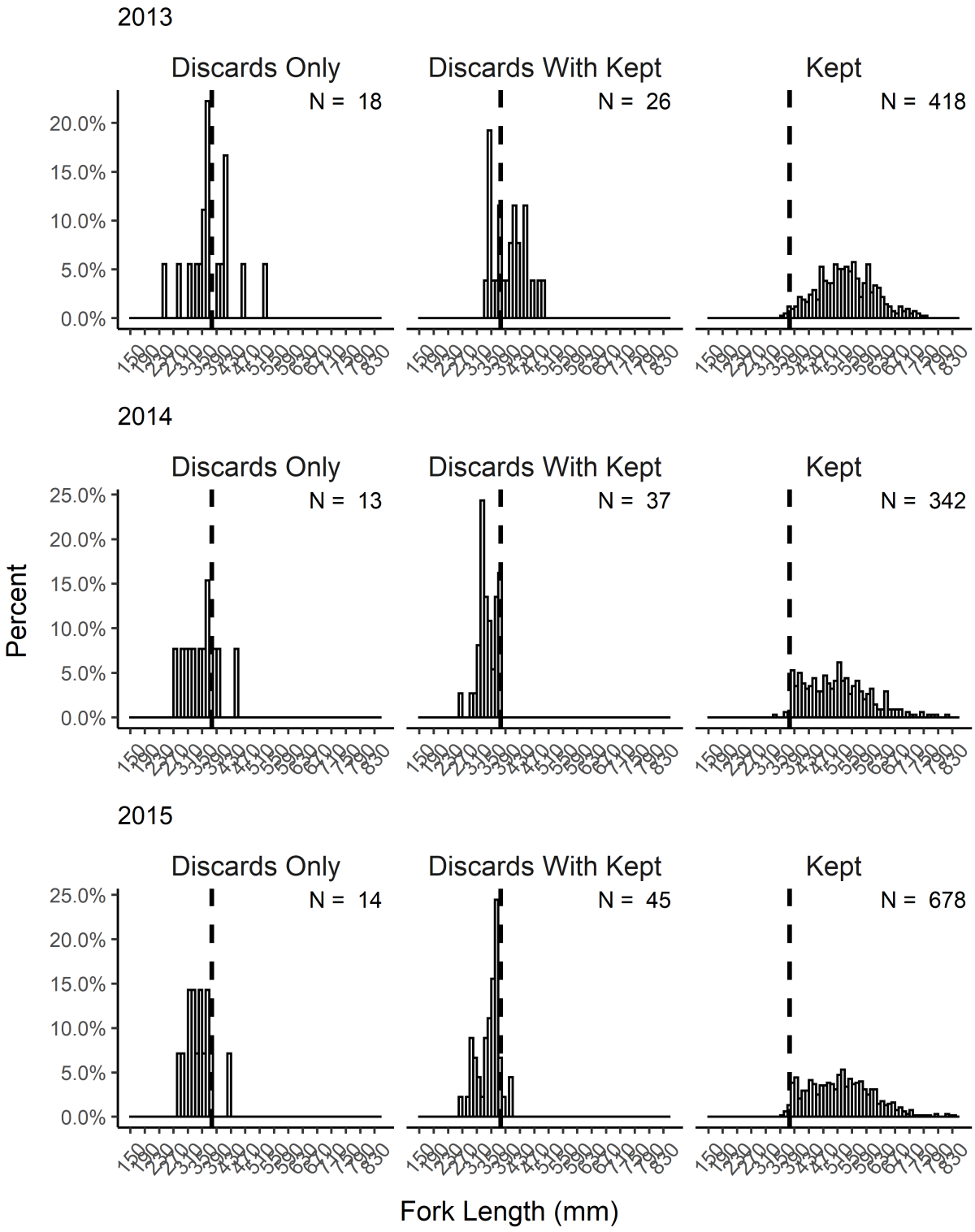


Figure 2. Length-frequency plots of observer vertical line GOM Scamp/Yellowmouth Grouper (YMG) by disposition (Kept or Discard) by year. 'Discards Only' were discards from trips with no kept Scamp/YMG; 'Discards with Kept' were discards from trips with kept Scamp/YMG. Vertical dashed lines denote the minimum size limit of 16" TL (377 mm FL); N is number of measured fish.




2010
Discards Only
Discards With Kept
Kept
N = 21
N = 50
N = 88
2011
Discards Only
Discards With Kept
Kept
N = 5
N = 18
N = 265
2012
Discards Only
Discards With Kept
Kept
N = 38
N = 112
N = 1340
Percent
Fork Length (mm)


2013
Discards Only
N = 18
Discards With Kept
N = 26
Kept
N = 418
2014
Discards Only
N = 13
Discards With Kept
N = 37
Kept
N = 342
2015
Discards Only
N = 14
Discards With Kept
N = 45
Kept
N = 678
Percent
Fork Length (mm)

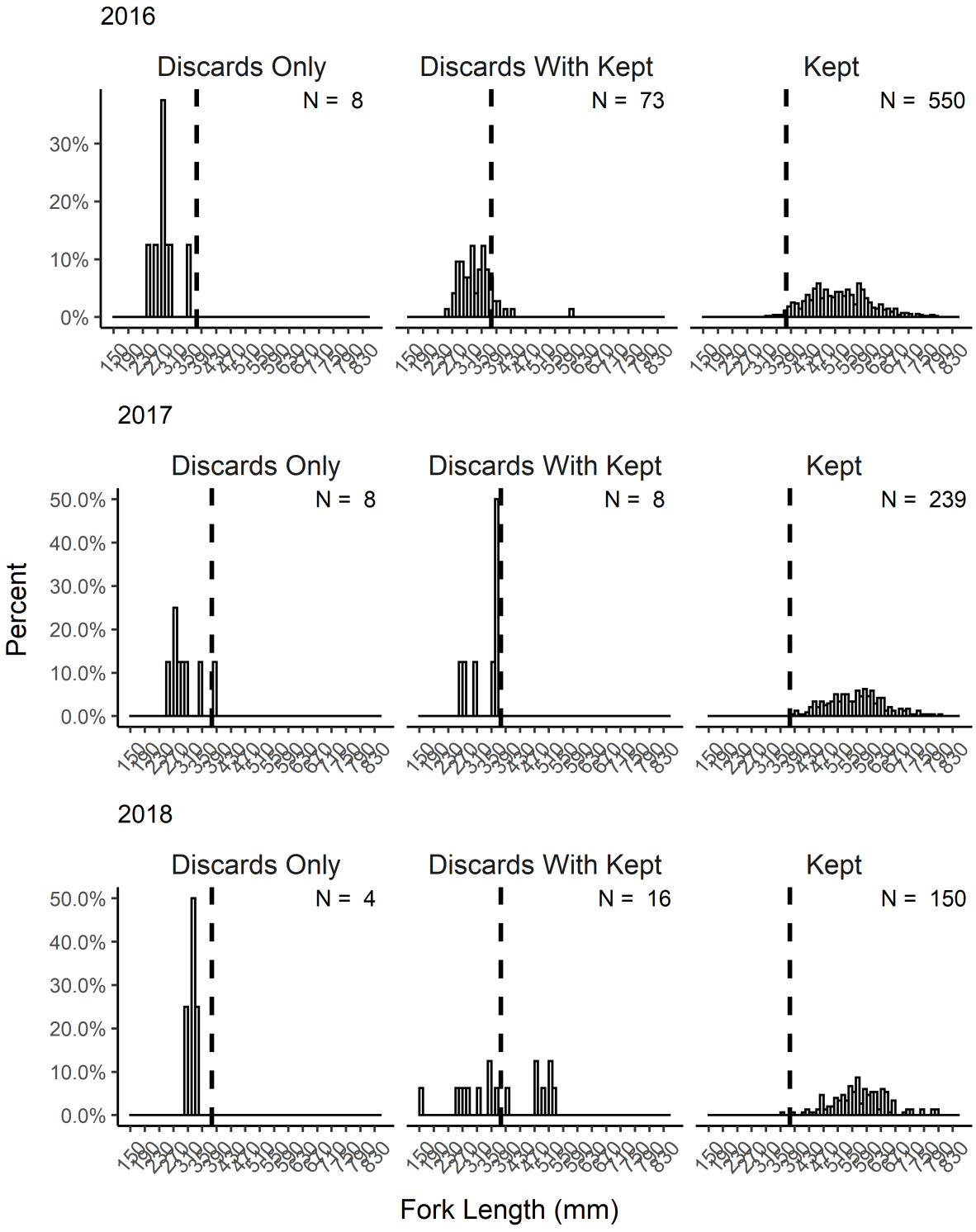

2016
Discards Only
N = 8
Discards With Kept
N = 73
Kept
N = 550
2017
Discards Only
N = 8
Discards With Kept
N = 8
Kept
N = 239
2018
Discards Only
N = 4
Discards With Kept
N = 16
Kept
N = 150
Percent
Fork Length (mm)

Figure 3. CPUE (catch in whole pounds per hour) time-series for logbook data from 2000 – 2018 for vertical line trips landing GOM Scamp/Yellowmouth Grouper. The vertical dashed lines denote the observer time period (2007-2018) and corresponding pre-IFQ (2007-2009) and IFQ (2010-2018) management regimes.

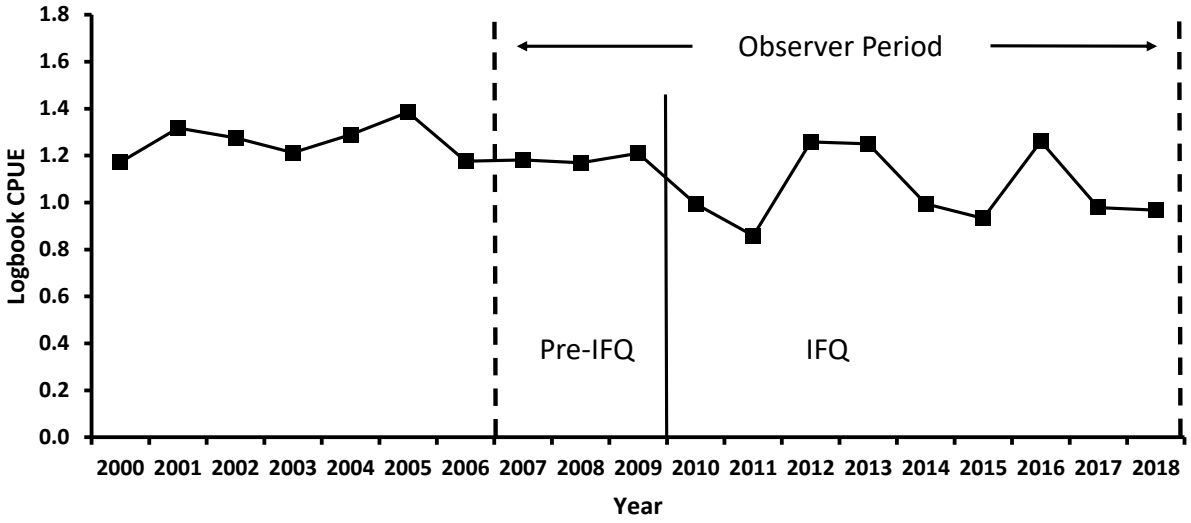


Figure 4. Comparison of vertical line reported annual logbook landings of GOM Scamp/Yellowmouth Grouper (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

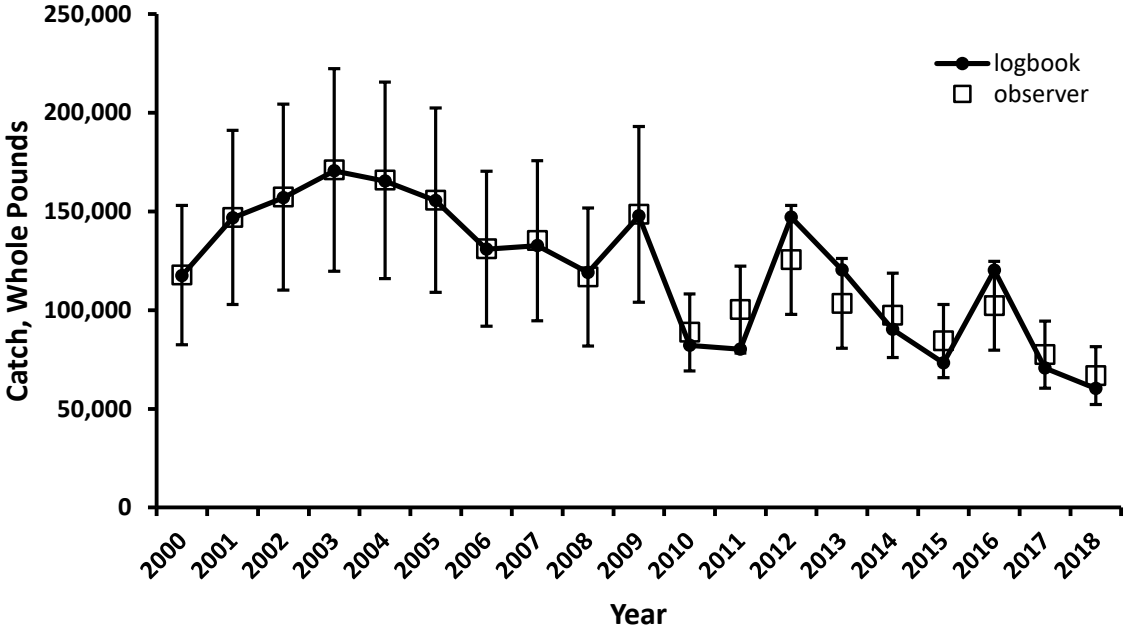
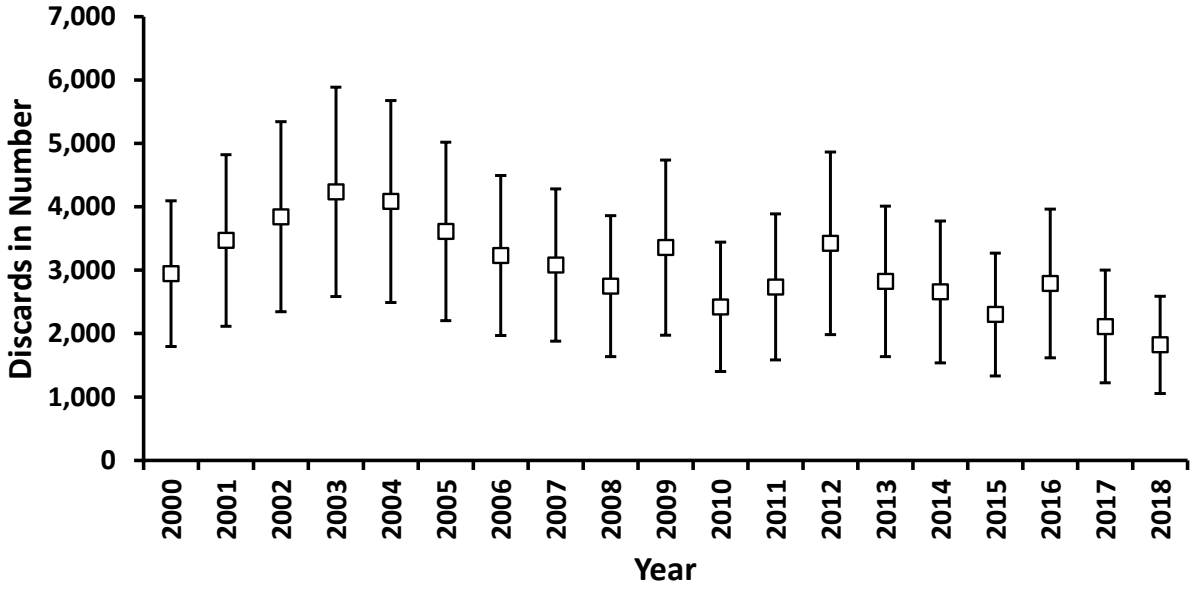


Figure 5. Observer CPUE expansion estimates of GOM Scamp/Yellowmouth Grouper vertical line annual discards (±SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 2000-2018.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch

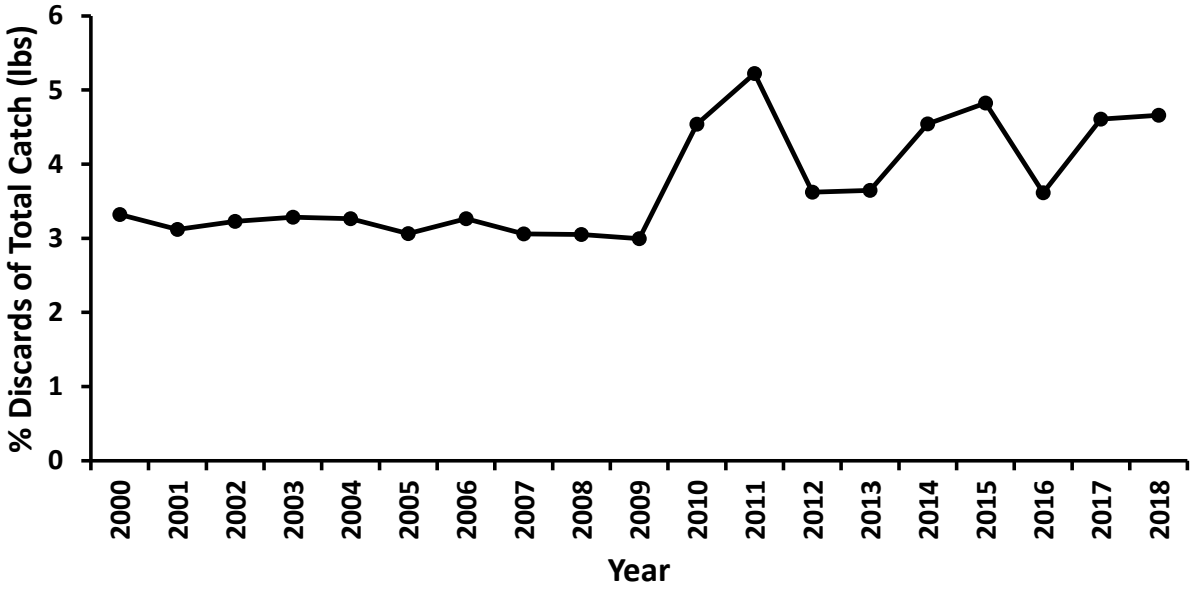
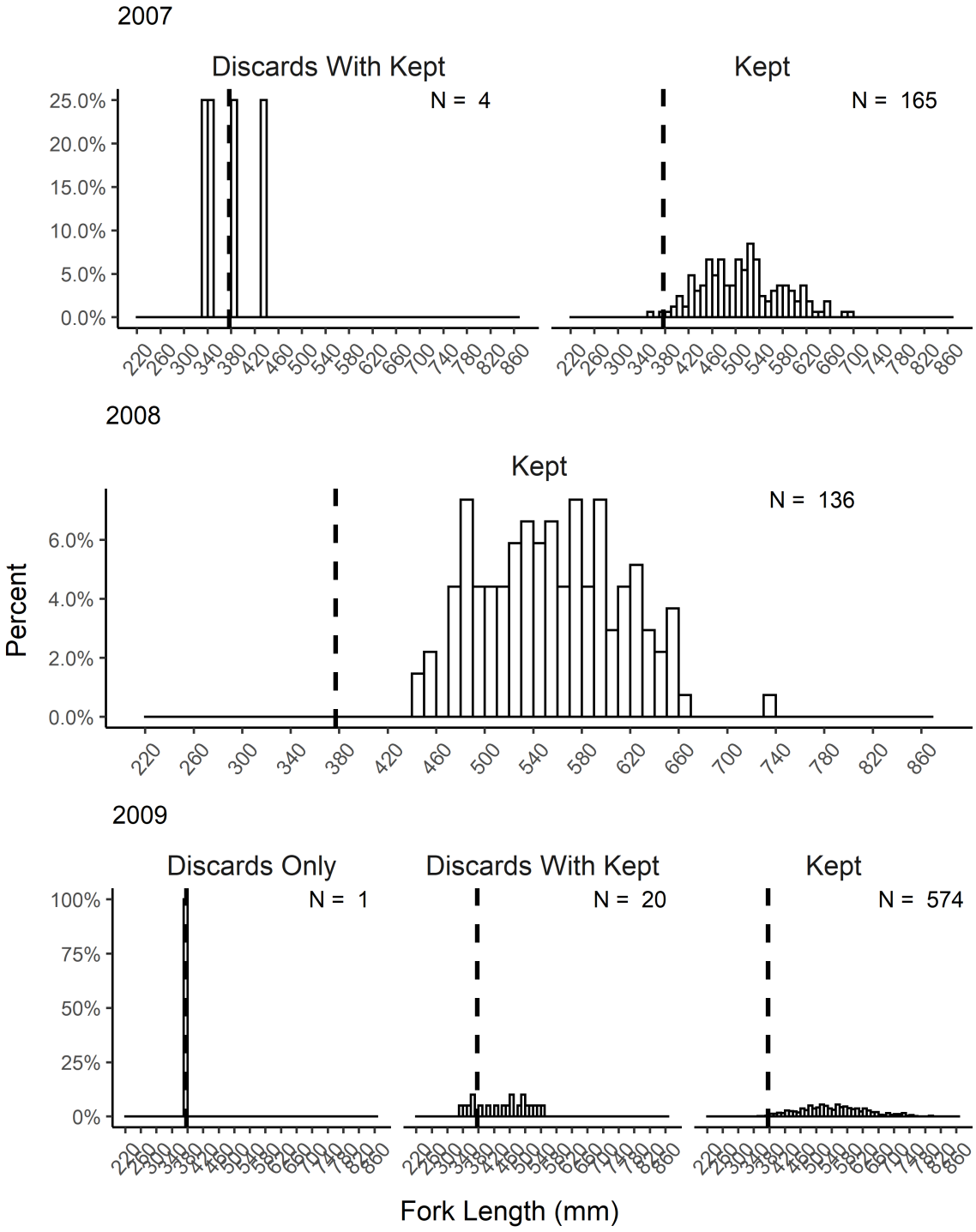
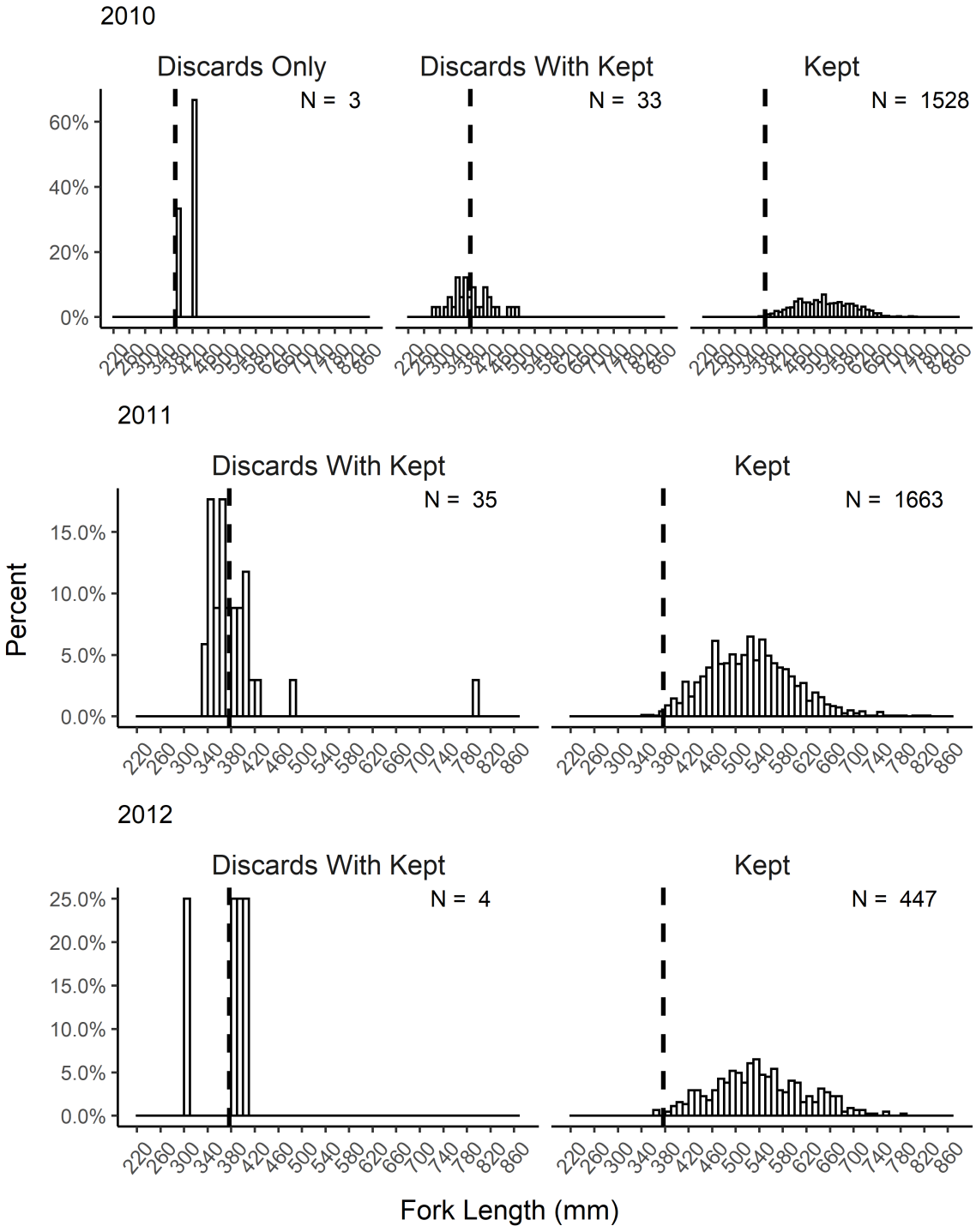
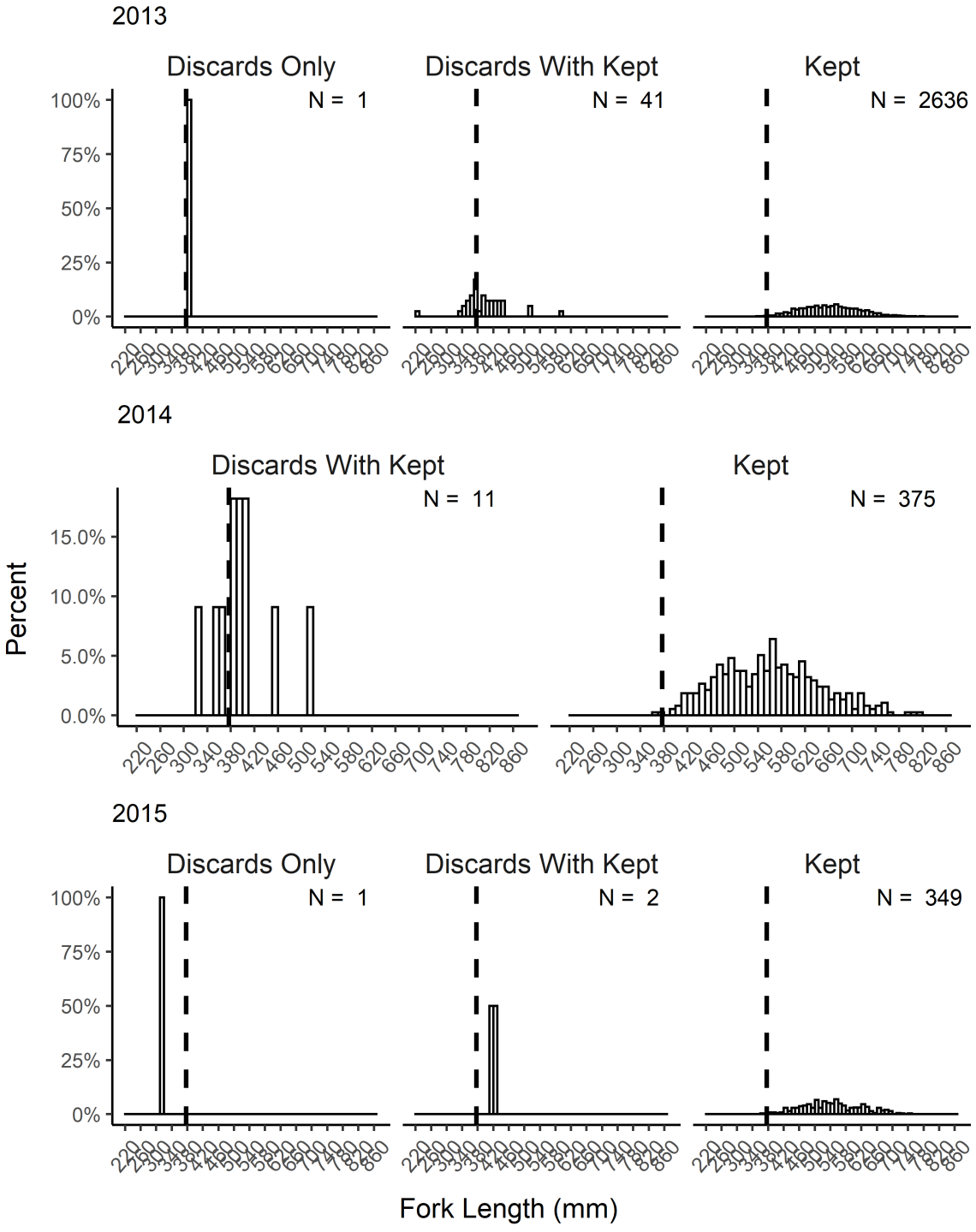


Figure 6. Length-frequency plots of observer bottom longline GOM Scamp/Yellowmouth Grouper (YMG) by disposition (Kept or Discard) by year. 'Discards Only' were discards from trips with no kept Scamp/YMG; 'Discards with Kept' were discards from trips with kept Scamp/YMG. Vertical dashed lines denote the minimum size limit of 16" TL (377 mm FL); N is number of measured fish.




2010
Discards Only
N = 3
Discards With Kept
N = 33
Kept
N = 1528
2011
Discards With Kept
N = 35
Kept
N = 1663
2012
Discards With Kept
N = 4
Kept
N = 447
Percent
Fork Length (mm)


2013
Discards Only
Discards With Kept
Kept
N = 1
N = 41
N = 2636
2014
Discards With Kept
Kept
N = 11
N = 375
2015
Discards Only
Discards With Kept
Kept
N = 1
N = 2
N = 349
Percent
Fork Length (mm)

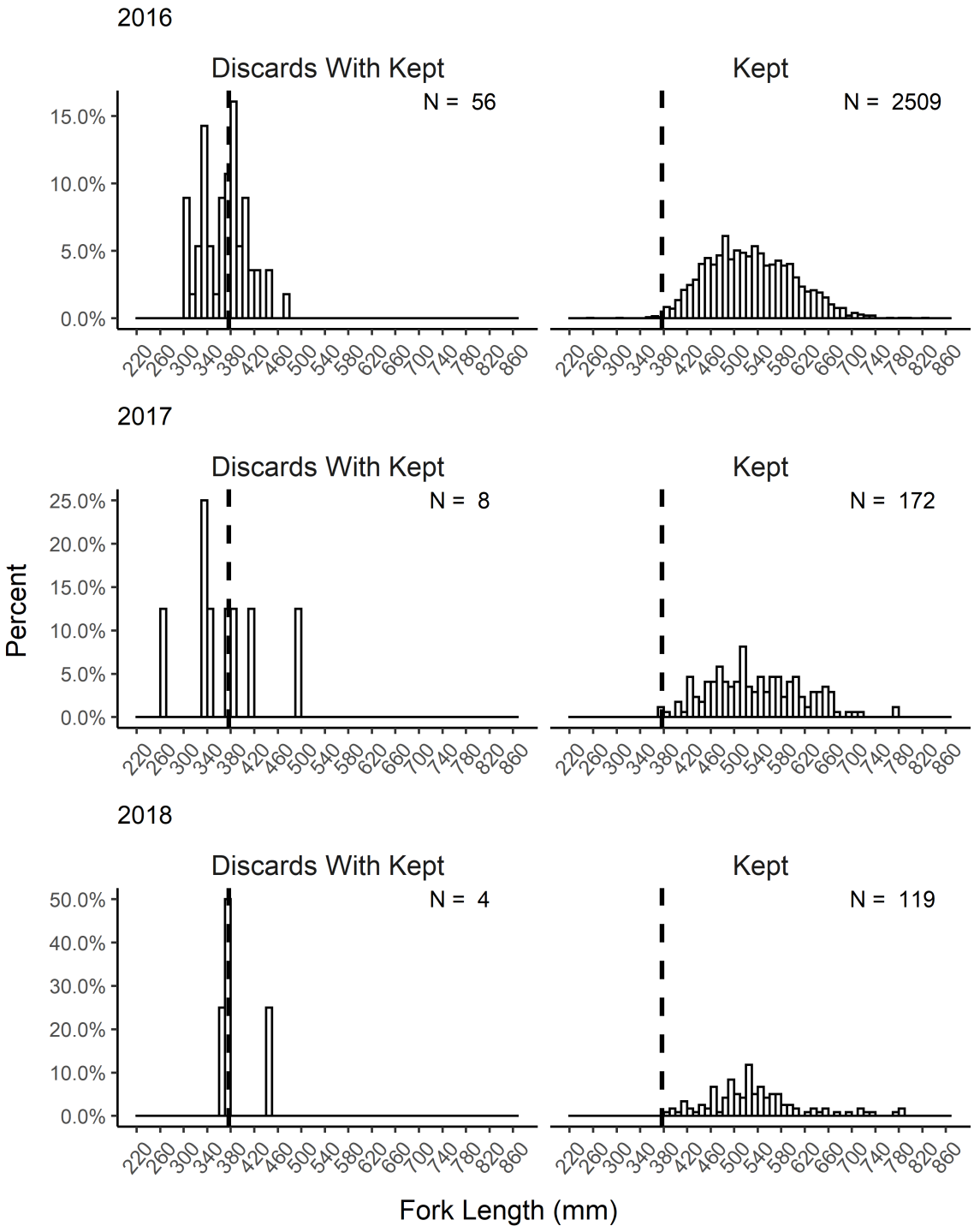

2016
Discards With Kept
N = 56
Kept
N = 2509
2017
Discards With Kept
N = 8
Kept
N = 172
2018
Discards With Kept
N = 4
Kept
N = 119
Percent
Fork Length (mm)

Figure 7. CPUE (catch in whole pounds per hour) time-series for logbook data from 2000 – 2018 for bottom longline trips landing GOM Scamp/Yellowmouth Grouper. The vertical dashed lines denote the observer time period (2007-2018) and corresponding pre-IFQ (2007-2009) and IFQ (2010-2018) management regimes.

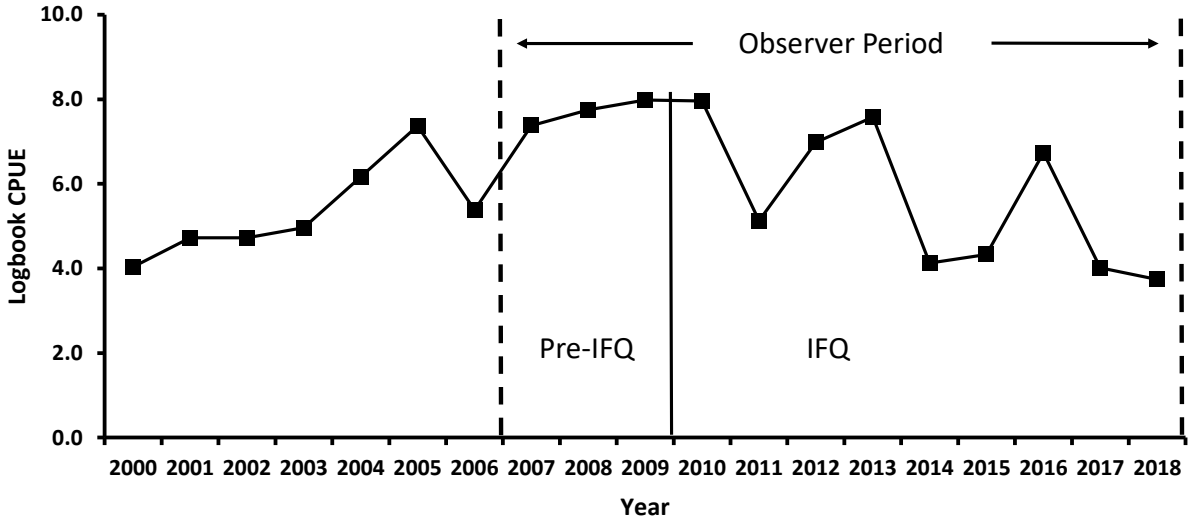


Figure 8. Comparison of bottom longline reported annual logbook landings of GOM Scamp/Yellowmouth Grouper (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

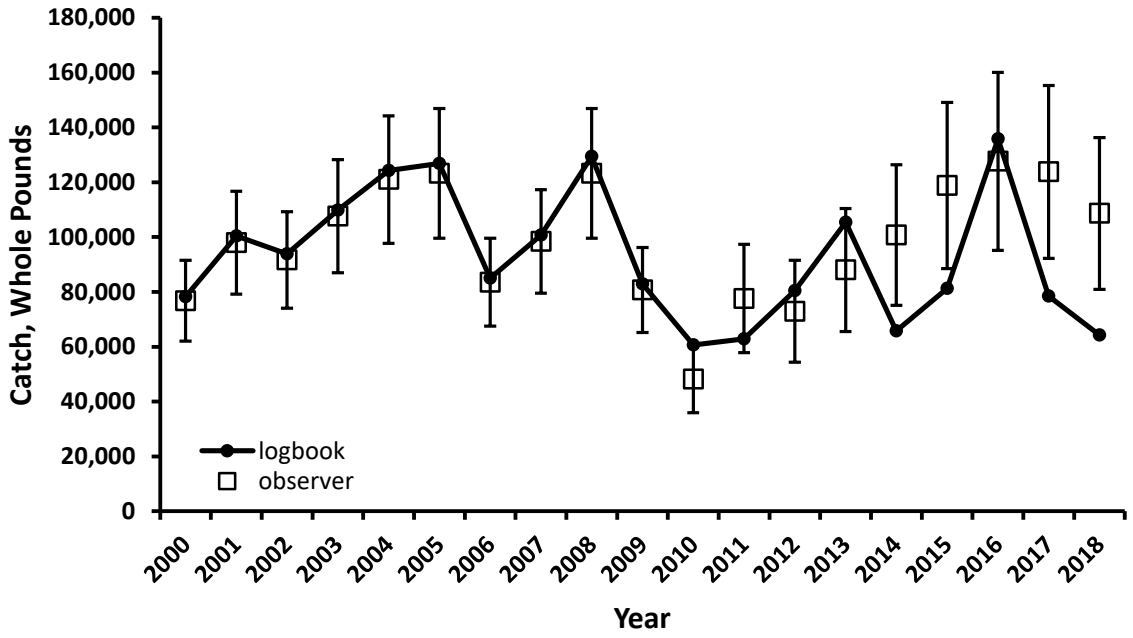
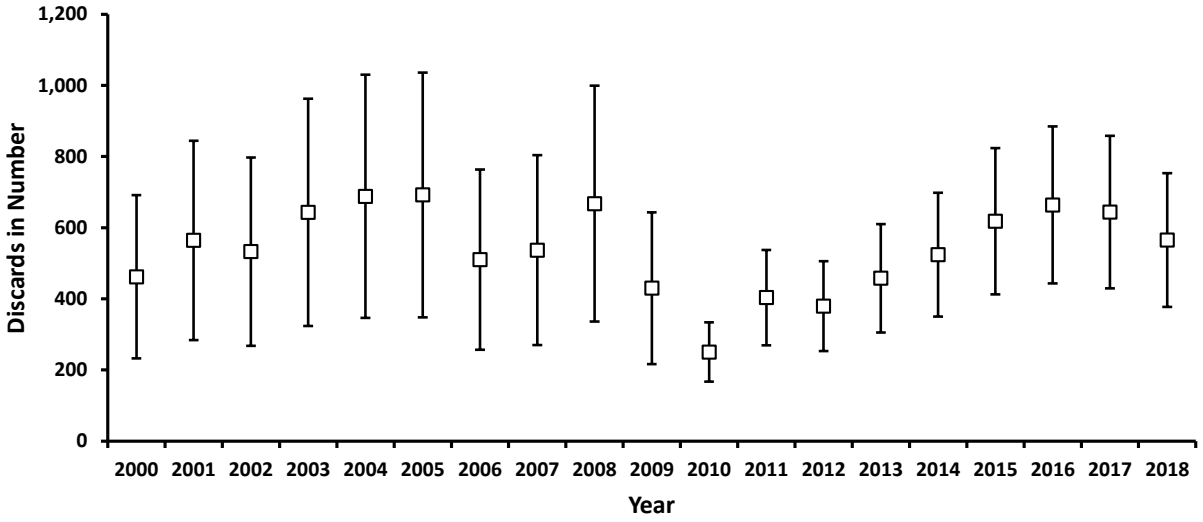


Figure 9. Observer CPUE expansion estimates of GOM Scamp/Yellowmouth Grouper bottom longline annual discards (±SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 2000-2018.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch