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CPUE Expansion Estimation for Commercial Discards of Gulf of Mexico Red Snapper

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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 reef fish observer program and total fishing effort from the commercial coastal 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 Red Snapper. Discard estimation was conducted separately for two gears, vertical line (VL) and bottom longline (BLL). A verification step compared annual total landed catch from logbook data with the estimated observer annual total landed catch. Once verified, Red Snapper annual total discards in weight and number were estimated for the observer data period 2007-2019 for each of the zones (East, Central, and West). For VL, the annual average of discards in weight accounted for about 12%, 44%, and 11% of the total catch for central, east, and west, respectively. For BLL, the average of discards to total catch was 118%, 127%, and 61% for central, east, and west, respectively.

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,

$$totalCatch = CPUE * totalEffort.$$

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 red snapper.

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 (Atkinson et al. 2021a, 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 Red Snapper discard estimation, complete calendars years 2007-2019 were used.

Total effort was determined from the commercial Coastal Fisheries Logbook Program in which fishers reported basic information on effort and catch by species for every trip (Atkinson et al. 2021b). For GOM Red Snapper discard estimation, complete calendar years 2007-2019 were considered.

Relevant Management History of GOM Red Snapper

The Reef Fish Observer Program started at the same time as the implementation of the Individual Fisheries Quota (IFQ) for the GOM red snapper fishery. As a result, hindcast discard estimation procedures for "Trending CPUE" described in Smith et al. (2019a) were not applied. This is because an appropriate time period for hindcasting prior to IFQ does not exist in the observer data. Therefore, the only key management change relevant to discard estimation from 2007-2019 was the establishment of a minimum size limit of 13" TL (12" FL) in early 2008.

Gear

In the coastal observer data Red Snapper 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):

$$\hat{C} = C\bar{P}UE * \hat{X},$$

where $C\bar{P}UE$ 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

$$C\bar{P}UE = \frac{\bar{y}}{\bar{x}},$$

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

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

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

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

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

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

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

$$s^2(y|x) = \frac{\Sigma_i(y_i - C\bar{P}UEx_i)^2}{n-1}.$$

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

$$var[\hat{C}] = var[C\bar{P}UE] * \hat{X}^2.$$

Standard error of total catch was calculated as

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

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

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

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 East (E), Central (C), and West (W) of the GOM, defined as statistical zones 1-6, 7-12, 13-21, respectively (Fig. 1).

Central Zone Bottom Longline

The Central Zone had a very low sample size resulting in developing a different approach to estimate discards. Since SEDAR 74 was a research track assessment, discard data providers conducted three methods of estimating discards for the Central Zone that were recommended by the stock assessment analysts. After discussions between the stock assessment analysts and the discard data providers one of the methods was selected to use for estimating the Central Zone discards. The different methods for estimating the Central Zone discards are described below.

Option 1. Discards were estimated for Central and East zones combined. The fleet-specific landing ratios between Central and East zones were computed using the logbook data. These ratios were used to proportion the Central Zone discards.

Option 2. The discard per unit effort and the proportion of observed discard only trips was borrowed from the West Zone. The logbook effort from the Central Zone was used to calculate the Central Zone discards.

Option 3. The discard per unit effort and the proportion of observed discard only trips was borrowed from the East Zone. The logbook effort from the Central Zone was used to calculate the Central Zone discards.

Results and Discussion

Vertical Line

The observer database included 1,324 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 red snapper and by zone. The management regimes were based on patterns in annual discard rates, length composition, and minimum size limit changes. For vertical line, the management regimes were classified as First (2007), Second (2008-2013), and Third (2014-2019).

The disposition (kept or discarded) of GOM red snapper by management regime included fish below and above the minimum size limit of 12" FL (305 mm FL) (Fig. 2). In 2007, discards were mostly fish near or above the minimum size limit, and kept fish were mostly above the minimum size limit. For 2008-2013 period, most of the fish discarded and kept fish were above the minimum size limit. Lastly, most of the fish discarded and kept fish were above the minimum size limit in 2014-2019.

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting red snapper by zone showed a positive trend for all the zones, the central zone presented more fluctuations than the other two zones (Fig. 3). Catch-effort data for observer trips catching red snapper were pooled across years for the respective management regimes. Logbook catch-effort data for red snapper 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 zones and management regimes.

Observer and logbook frequency distributions of trip-level catch, effort, and CPUE were similar for only the first and second management regime for the central zone, and the second management regime for the west zone, suggesting that observer sampling of red snapper trips was representative of the commercial fleet. For all other management regimes and zones, further analysis showed a discrepancy between observer and logbook catch. To account for this discrepancy, observer and logbook trips were grouped into strata according to low (L), moderate (M), and/or high (H) catches for subsequent analysis and estimation (Table 2).

The proportions of observer trips and effort encountering red snapper 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 red snapper trips and effort (Table 4) to account for logbook trips that only had discarded fish. Estimates of observer mean CPUE, in weight and number, by management regime and catch level strata are given in Table 5. These CPUEs were the basis for expansion estimates of red snapper catch and discards.

CPUE expansion estimates of annual total landed catch of GOM red snapper compared fairly with reported logbook landings for all the zones (Fig. 4). CPUE expansion estimates for annual discards in numbers and weight of GOM red snapper for each zone are provided in Table 6. Estimated discards in number by year showed different trends across zones (Fig. 5A). The percentage of discards, in weight, to the total catch (kept + discards) presented a negative trend in all zones (Fig. 5B).

Bottom Longline

The observer database included 415 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 red snapper by zone. Due to the small sample size, the management regime for bottom longline was aggregated for all years (2007-2019). The disposition (kept or discarded) of GOM red snapper showed mostly fish above the minimum size limit of 12" FL (305 mm FL) (Fig. 6).

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting red snapper by zone showed an irregular increase in CPUE in the east zone, and a decrease in CPUE for the west zone (Fig. 7). Observer and logbook catch-effort data for red snapper trips were

pooled across years. These observer and logbook datasets were the basis for subsequent analysis and estimation of catch and discards for the east and west zones.

For the west zone, further analysis showed that observers sampled a higher proportion of low catch (<= 694 lbs.) red snapper trips and a lower proportion of high catch (>694 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 red snapper that had kept fish are given in Table 9 by zone and catch level strata. These proportions were used to adjust annual logbook total red snapper trips and effort (Table 10) to account for logbook trips that only had discarded fish. Estimates of observer mean CPUE by zone and catch level strata are given in Table 11. These CPUEs were the basis for expansion estimates of red snapper catch and discards.

For east and west zone, CPUE expansion estimates of annual total landed catch of GOM red snapper compared favorably with reported logbook landings for 2007-2019 (Fig. 8). CPUE expansion estimates for annual discards in numbers and weight of GOM red snapper are provided in Table 12 by zone. Estimated discards in number showed an irregular trend for the west zone, and a positive trend in the east zone (Fig. 9A). The average of discards in weight accounted for more than 100% of the total catch (kept + discards) in the east zone, and 61% for the west zone (Fig. 9B).

Central Zone Bottom Longline

A different approach of estimating discards was used for the central zone due to the low sample size (Table 7). The option 1 was selected as the best approach for central zone discards. The option 1 consisted of the estimation of catch and discards combining the central and east zones, and using the logbook landings from the central zone to proportion the combined discards to estimate the central zone discards. Comparisons of the time-series of CPUE expansion estimates of discards in weight and number with the standard error for the three options suggested that option 1 better estimated the central zone discards. Option 1 was selected because the central zone is ecologically similar to the east zone, and previous red snapper stock assessments have been conducted by combining the central and east zones (SEDAR 52).

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting red snapper for the central zone showed an irregular increase (Fig. 10). The CPUE expansion estimates for annual discards in numbers and weight of GOM red snapper are provided in Table 13. Estimated discards in number showed an irregular trend (Fig. 11A) and the average of discards in weight accounted for more than 100% of the total catch (kept + discards) with a decreasing trend (Fig. 11B).

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Table 1. Number of total and Red Snapper coastal observer vertical line trips by year for the GOM.

	Central Zone		Eastern Zone		Western Zone	
Year	Total Observer Trips	Red Snapper Observer Trips	Total Observer Trips	Red Snapper Observer Trips	Total Observer Trips	Red Snapper Observer Trips
2007	44	43	34	28	19	17
2008	15	12	23	17	15	15
2009	20	19	19	13	7	5
2010	19	20	31	20	6	5
2011	41	41	51	34	13	10
2012	98	95	122	86	34	34
2013	53	53	60	25	12	9
2014	41	36	50	31	18	16
2015	74	72	92	50	35	35
2016	44	42	73	46	25	24
2017	26	24	29	19	12	12
2018	15	16	16	12	8	8
2019	13	13	9	8	8	8

Table 2. Definition of trip catch level strata for GOM Red Snapper, and corresponding percentages of logbook and observer vertical line trips for each zone and management regime.

Zone (C) Management Regime (Third (2014-2019))

		% Trips	
Trip Catch Level	Stratum Code	Logbook	Observer
Low, catch <= 522 lbs	L	43.9	60.6
High, catch > 522 lbs	H	56.1	39.4

Zone (E) Management Regime (First (2007))

		% Trips	
Trip Catch Level	Stratum Code	Logbook	Observer
Low, catch <= 144 lbs	L	58.5	85.7
High, catch > 144 lbs	H	41.5	14.3

Zone (E) Management Regime (Second (2008-2013))

Trip Catch Level	Stratum Code	% Trips	
		Logbook	Observer
Low, catch <= 56 lbs	L	26.5	48.2
Moderate, 56< catch <= 152 lbs	M	25.1	11.3
High, catch > 152 lbs	H	48.4	40.5

Zone (E) Management Regime (Third (2014-2019))

Trip Catch Level	Stratum Code	% Trips	
		Logbook	Observer
Low, catch <= 34 lbs	L	18.7	41.0
Moderate, 34< catch <= 133 lbs	M	27.2	18.7
High, catch > 133 lbs	H	54.1	40.4

Zone (W) Management Regime (First (2007))

Trip Catch Level	Stratum Code	% Trips	
		Logbook	Observer
Low, catch <= 1486 lbs	L	50	76.5
High, catch > 1486 lbs	H	50	23.5

Zone (W) Management Regime (Third (2014-2019))

Trip Catch Level	Stratum Code	% Trips	
		Logbook	Observer
Low, catch <= 749 lbs	L	30.6	29.1
Moderate, 749< catch <= 2880 lbs	M	23.3	16.5
High, catch > 2880 lbs	H	46.2	54.4

Table 3. Red Snapper vertical line trip and effort adjustment factors by management regime and catch level strata in GOM. Catch level strata are defined in Table 2; catch level stratum 'A' is all levels (i.e., no stratification) for the management regime, "H", "M" and "L" are high, moderate and low, respectively. The proportions of Red Snapper observer trips and effort with kept Red Snapper were used to respectively adjust annual logbook total trips and effort (Table 4) to account for logbook trips that only had discarded fish.

Zone (C)

Management Regime	Catch Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Red Snapper	
			Trips	Effort
First (2007)	A	43	0.674	0.774
Second (2008-2013)	A	240	0.867	0.875
Third (2014-2019)	H	80	1	1
Third (2014-2019)	L	123	0.927	0.938

Zone (E)

Management Regime	Catch Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Red Snapper	
			Trips	Effort
First (2007)	H	4	1	1
First (2007)	L	24	0.333	0.317
Second (2008-2013)	H	79	1	1
Second (2008-2013)	L	94	0.479	0.505
Second (2008-2013)	M	22	1	1
Third (2014-2019)	H	67	1	1
Third (2014-2019)	L	68	0.632	0.579
Third (2014-2019)	M	31	1	1

Zone (W)

Management Regime	Catch Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Red Snapper	
			Trips	Effort
First (2007)	H	4	1	1
First (2007)	L	13	0.923	0.965
Second (2008-2013)	A	78	0.936	0.937
Third (2014-2019)	H	56	1	1
Third (2014-2019)	L	30	0.8	0.85
Third (2014-2019)	M	17	1	1

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

Zone (C)

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2007	A	1,246	1,848	46,343	59,882
2008	A	1,195	1,379	39,828	45,543
2009	A	1,282	1,479	41,452	47,400
2010	A	1,505	1,737	46,813	53,530
2011	A	1,726	1,992	56,872	65,033
2012	A	1,803	2,080	62,282	71,219
2013	A	1,613	1,861	49,930	57,095
2014	H	753	753	27,138	27,138
2014	L	889	959	22,170	23,624
2015	H	1,011	1,011	31,282	31,282
2015	L	721	778	15,190	16,186
2016	H	938	938	30,992	30,992
2016	L	855	922	21,501	22,911
2017	H	1,083	1,083	33,646	33,646
2017	L	821	886	19,238	20,500
2018	H	1,004	1,004	28,699	28,699
2018	L	679	733	15,259	16,260
2019	H	1,041	1,041	30,061	30,061
2019	L	601	648	13,667	14,563

Zone (E)

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2007	H	107	107	6,944	6,944
2007	L	151	453	7,853	24,750
2008	H	95	95	5,975	5,975
2008	L	94	196	3,981	7,884
2008	M	67	67	3,708	3,708
2009	H	133	133	7,094	7,094
2009	L	126	263	6,633	13,135
2009	M	91	91	5,001	5,001
2010	H	225	225	14,452	14,452

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2010	L	163	340	7,925	15,694
2010	M	146	146	8,364	8,364
2011	H	398	398	23,180	23,180
2011	L	172	359	7,237	14,332
2011	M	170	170	8,311	8,311
2012	H	379	379	20,438	20,438
2012	L	179	374	7,666	15,181
2012	M	192	192	8,860	8,860
2013	H	474	474	28,526	28,526
2013	L	199	416	6,900	13,663
2013	M	218	218	9,583	9,583
2014	H	498	498	27,559	27,559
2014	L	203	321	7,424	12,821
2014	M	302	302	12,328	12,328
2015	H	492	492	23,827	23,827
2015	L	225	356	9,460	16,337
2015	M	272	272	12,064	12,064
2016	H	641	641	33,800	33,800
2016	L	232	367	7,015	12,114
2016	M	345	345	13,256	13,256
2017	H	686	686	32,894	32,894
2017	L	202	319	5,058	8,735
2017	M	382	382	14,289	14,289
2018	H	728	728	30,837	30,837
2018	L	206	326	4,484	7,744
2018	M	329	329	8,222	8,222
2019	H	742	742	31,017	31,017
2019	L	241	381	3,802	6,565
2019	M	276	276	5,870	5,870

Zone (W)

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2007	H	442	442	25,755	25,755
2007	L	442	479	13,884	14,387
2008	A	604	645	26,629	28,419

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2009	A	506	541	22,558	24,074
2010	A	449	480	18,603	19,854
2011	A	476	509	18,362	19,597
2012	A	499	533	20,884	22,288
2013	A	433	463	20,380	21,750
2014	H	274	274	12,639	12,639
2014	L	136	170	1,810	2,130
2014	M	133	133	4,097	4,097
2015	H	361	361	16,493	16,493
2015	L	192	240	1,345	1,582
2015	M	144	144	3,471	3,471
2016	H	341	341	15,079	15,079
2016	L	235	294	1,517	1,785
2016	M	127	127	2,796	2,796
2017	H	331	331	14,236	14,236
2017	L	237	296	1,790	2,105
2017	M	150	150	2,963	2,963
2018	H	268	268	11,322	11,322
2018	L	229	286	2,227	2,620
2018	M	181	181	4,544	4,544
2019	H	286	286	11,808	11,808
2019	L	204	255	2,478	2,916
2019	M	203	203	5,465	5,465

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

Zone (C)

			Observer CPUE	
Management Regime	Catch Level	Logbook CPUE	Kept	Discard
First (2007)	A	13.305	14.142	1.975
Second (2008-2013)	A	20.922	21.216	3.144
Third (2014-2019)	H	55.995	54.753	2.834
Third (2014-2019)	L	9.910	9.502	1.943

Zone (E)

			Observer CPUE	
Management Regime	Catch Level	Logbook CPUE	Kept	Discard
First (2007)	H	6.211	6.214	1.717
First (2007)	L	0.391	0.374	0.781
Second (2008-2013)	H	8.542	7.559	2.169
Second (2008-2013)	L	0.311	0.156	2.809
Second (2008-2013)	M	1.993	2.041	2.897
Third (2014-2019)	H	10.342	10.239	1.475
Third (2014-2019)	L	0.326	0.192	0.918
Third (2014-2019)	M	2.187	1.381	0.681

Zone (W)

			Observer CPUE	
Management Regime	Catch Level	Logbook CPUE	Kept	Discard
First (2007)	H	63.299	72.262	27.088
First (2007)	L	20.080	18.206	0.981
Second (2008-2013)	A	70.364	70.350	9.905
Third (2014-2019)	H	141.928	122.077	4.173
Third (2014-2019)	L	32.627	15.003	4.835
Third (2014-2019)	M	69.543	72.082	0.485

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

Zone (C)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2007	118,238	22,475	83,383	13,829
2008	143,175	38,570	49,728	12,146
2009	149,013	40,143	51,756	12,642
2010	168,285	45,335	58,449	14,276

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2011	204,447	55,076	71,009	17,344
2012	223,893	60,315	77,763	18,994
2013	179,491	48,353	62,341	15,227
2014	122,821	44,250	66,197	19,524
2015	120,115	43,275	66,713	19,676
2016	132,360	47,687	72,065	21,255
2017	135,196	48,709	74,438	21,954
2018	112,937	40,689	62,429	18,413
2019	113,501	40,892	63,248	18,654

Zone (E)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2007	31,260	7,571	8,544	1,950
2008	45,852	10,876	8,598	2,143
2009	66,779	15,841	12,487	3,113
2010	99,671	23,643	18,723	4,667
2011	114,624	27,190	21,726	5,416
2012	112,653	26,722	21,279	5,304
2013	128,029	30,369	24,330	6,065
2014	60,809	19,402	24,623	10,420
2015	58,352	18,618	22,530	9,534
2016	69,996	22,334	29,146	12,333
2017	66,261	21,142	28,138	11,907
2018	58,186	18,566	25,139	10,638
2019	55,768	17,794	24,532	10,381

Zone (W)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2007	711,751	421,446	466,911	266,427
2008	281,484	107,565	131,928	62,846
2009	238,446	91,118	111,757	53,237
2010	196,645	75,145	92,165	43,904
2011	194,100	74,172	90,972	43,336

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2012	220,756	84,358	103,466	49,287
2013	215,423	82,321	100,966	48,097
2014	65,024	29,304	27,537	12,480
2015	78,156	35,222	33,730	15,286
2016	72,909	32,857	31,153	14,118
2017	71,023	32,007	30,071	13,628
2018	62,115	27,993	25,897	11,736
2019	66,023	29,754	27,497	12,462

Table 7. Number of total and Red Snapper coastal observer bottom longline trips by year for the GOM.

	Central Zone		**Eastern Zone**		**Western Zone**	
Year	Total Observer Trips	Red Snapper Observer Trips	Total Observer Trips	Red Snapper Observer Trips	Total Observer Trips	Red Snapper Observer Trips
2007	0	0	11	8	0	0
2008	0	0	3	2	2	2
2009	5	2	24	20	4	4
2010	3	1	43	37	7	4
2011	7	2	69	69	5	4
2012	2	1	15	15	2	1
2013	9	3	70	65	3	2
2014	3	1	23	21	1	1
2015	2	0	22	21	2	2
2016	4	1	43	42	8	7
2017	1	1	11	9	2	2
2018	0	0	4	4	0	0
2019	1	0	4	4	0	0

Table 8. Definition of trip catch level strata for GOM Red Snapper, and corresponding percentages of logbook and observer bottom longline trips for the western zone and all years.

Zone (W)

Trip Catch Level	Stratum Code	% Trips	
		Logbook	Observer
Low, catch <= 694 lbs	L	39.7	65.5
High, catch > 694 lbs	H	60.3	34.5

Table 9. Red Snapper bottom longline trip and effort adjustment factors by zone and catch level strata in GOM. Catch level strata are defined in Table 8; catch level stratum 'All' is all levels (i.e., no stratification) for the management regime, "H" and "L" are high and low, respectively. The proportions of Red Snapper observer trips and effort with kept Red Snapper were used to respectively adjust annual logbook total trips and effort (Table 10) to account for logbook trips that only had discarded fish.

Zone	Catch Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Red Snapper	
			Trips	Effort
East	A	317	0.672	0.693
West	H	10	1	1
West	L	19	0.474	0.455

Table 10. Annual time-series of bottom longline logbook trips (number) and effort (hours) by catch level strata for GOM Red Snapper.

Zone (E)

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted
2007	A	50	74	1,304	1,880
2008	A	72	107	1,808	2,607
2009	A	29	43	832	1,200
2010	A	159	237	4,601	6,635
2011	A	200	298	6,092	8,785
2012	A	149	222	3,815	5,501
2013	A	230	342	6,349	9,155
2014	A	248	369	7,915	11,413
2015	A	359	534	11,828	17,056
2016	A	372	554	11,976	17,269
2017	A	346	515	12,308	17,748
2018	A	357	531	12,168	17,546
2019	A	461	686	14,924	21,520

Zone (W)

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted
2007	H	27	27	836	836
2007	L	4	8	39	86
2008	H	22	22	855	855
2008	L	12	25	343	754
2009	H	23	23	898	898
2009	L	18	38	741	1,629
2010	H	8	8	221	221
2010	L	12	25	296	651
2011	H	4	4	96	96
2011	L	4	8	92	202
2012	H	5	5	128	128
2012	L	13	27	247	543
2013	H	13	13	651	651
2013	L	18	38	787	1,730
2014	H	13	13	825	825
2014	L	6	13	364	800

		Logbook Trips		Logbook Effort	
Year	Catch Level	Reported	Adjusted (N)	Reported	Adjusted
2015	H	12	12	627	627
2015	L	19	40	1,573	3,459
2016	H	21	21	1,231	1,231
2016	L	8	17	645	1,418
2017	H	17	17	838	838
2017	L	13	27	810	1,781
2018	H	18	18	655	655
2018	L	3	6	211	464
2019	H	33	33	1,486	1,486
2019	L	12	25	603	1,326

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

			Observer CPUE	
Zone	Catch Level	Logbook CPUE	Kept	Discard
East	A	11.412	8.933	11.238
West	H	55.512	52.928	8.771
West	L	2.634	2.696	14.640

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

Zone (E)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2007	21,132	4,884	2,953	645
2008	29,300	6,772	4,094	895
2009	13,483	3,116	1,884	412
2010	74,562	17,234	10,418	2,277
2011	98,725	22,819	13,795	3,014
2012	61,825	14,290	8,639	1,888
2013	102,890	23,782	14,377	3,141
2014	128,268	29,648	17,923	3,916

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2015	191,681	44,305	26,783	5,852
2016	194,079	44,859	27,118	5,926
2017	199,460	46,103	27,870	6,090
2018	197,191	45,579	27,553	6,021
2019	241,854	55,902	33,794	7,384

Zone (W)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2007	8,588	8,109	878	785
2008	18,541	17,507	1,808	1,617
2009	31,730	29,960	3,042	2,720
2010	11,467	10,827	1,090	975
2011	3,804	3,591	364	325
2012	9,074	8,568	858	767
2013	31,045	29,312	2,955	2,643
2014	18,954	17,896	1,844	1,649
2015	56,136	53,004	5,293	4,733
2016	31,561	29,800	3,057	2,734
2017	33,425	31,560	3,195	2,857
2018	12,538	11,838	1,230	1,100
2019	32,446	30,635	3,163	2,829

Table 13. Time-series of CPUE expansion estimates of Central Zone for GOM Red Snapper bottom longline discards in weight (lbs.) and number (with associated standard errors).

Zone (C)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2007	20,092	4,691	2,798	618
2008	20,934	4,887	2,916	644
2009	7,802	1,821	1,087	240
2010	10,874	2,539	1,515	335
2011	5,772	1,348	804	178
2012	1,476	345	206	45
2013	2,226	520	310	69
2014	8,917	2,082	1,242	274
2015	28,049	6,548	3,907	863
2016	13,158	3,072	1,833	405
2017	5,066	1,183	706	156
2018	24,336	5,682	3,390	749
2019	15,805	3,690	2,201	486

Figure 1. Map of sampling areas in the Gulf of Mexico

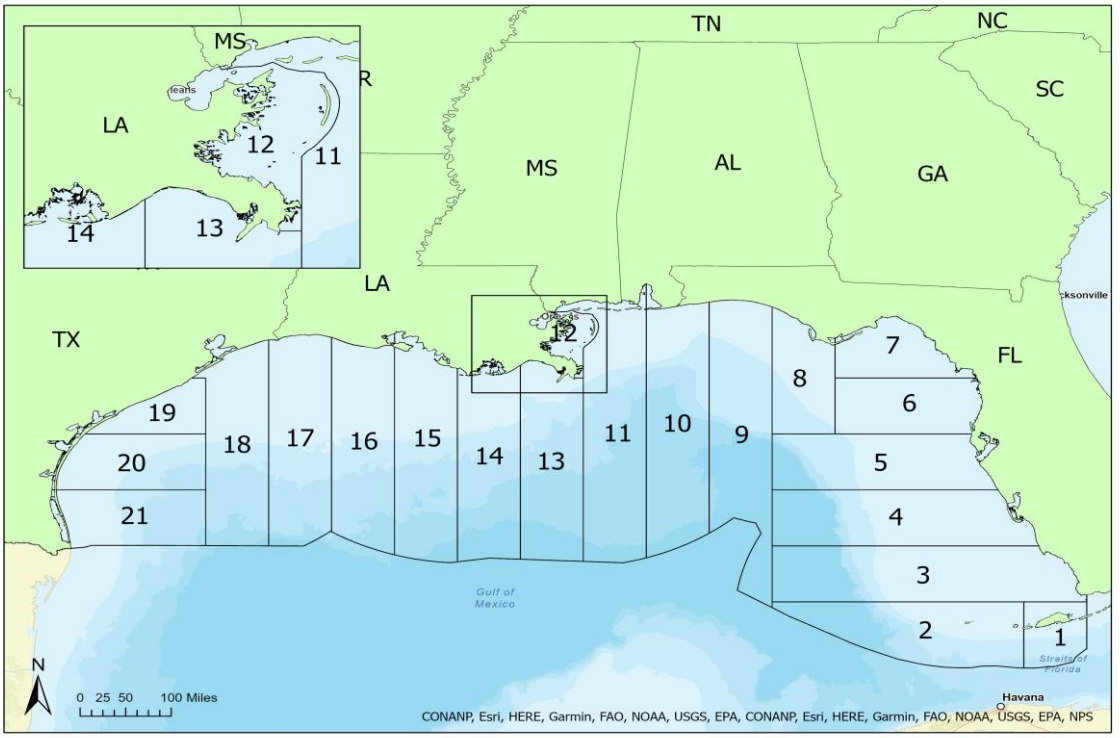
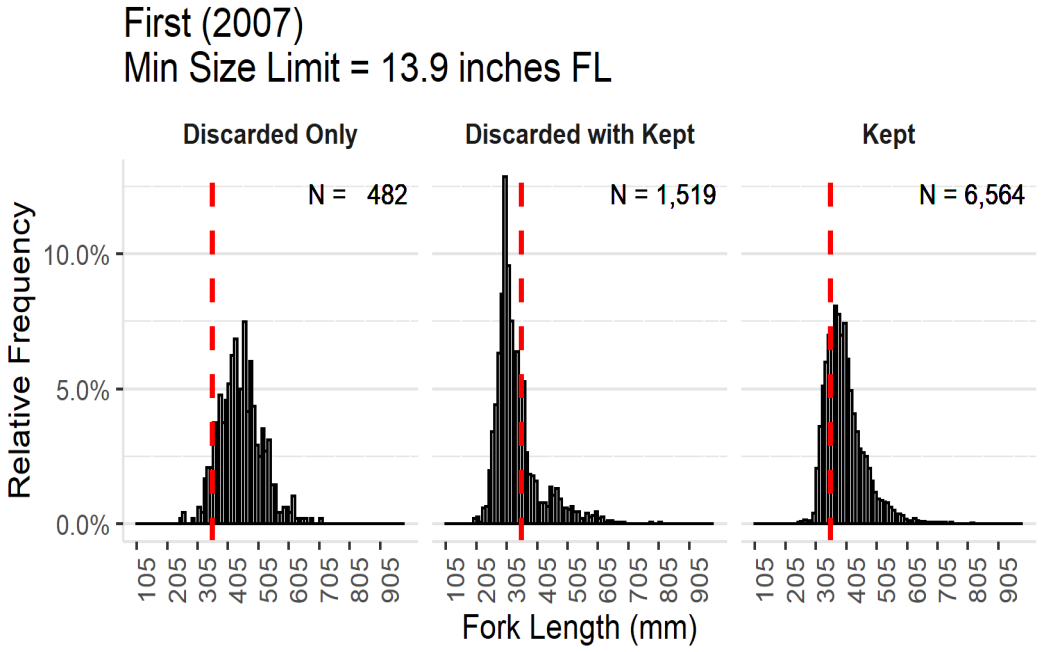
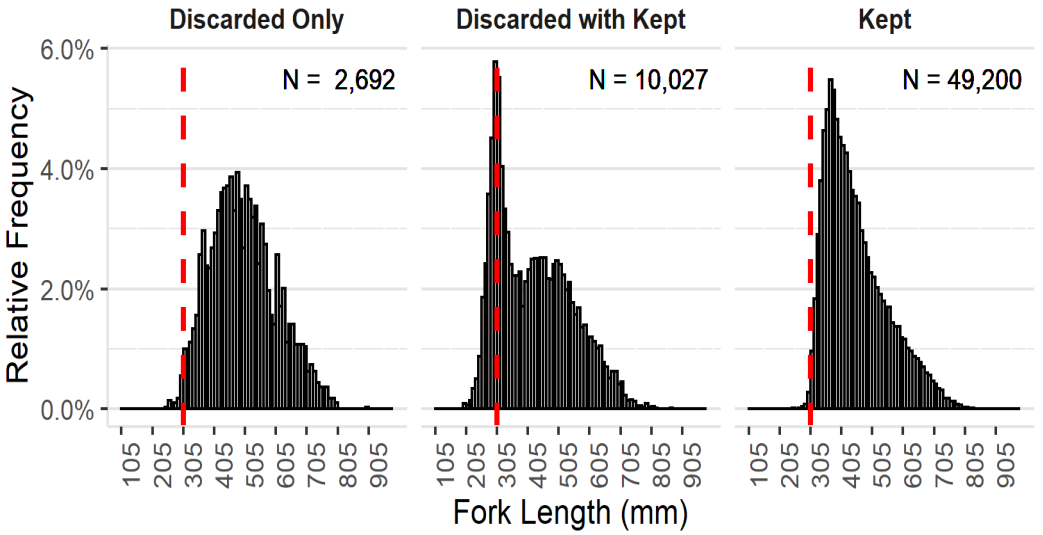


Figure 2. Length-frequency plots of observer vertical line GOM Red Snapper by disposition (Kept or Discard) and management regime. "Discarded Only" were discards from trips with no kept Red Snapper; "Discarded with Kept" were discards from trips with kept Red Snapper. Vertical dashed line denote the minimum size limit in fork length (FL); N is the number of measured fish.



Second (2008-2013)
Min Size Limit = 12 inches FL



Third (2014-2019)
Min Size Limit = 12 inches FL

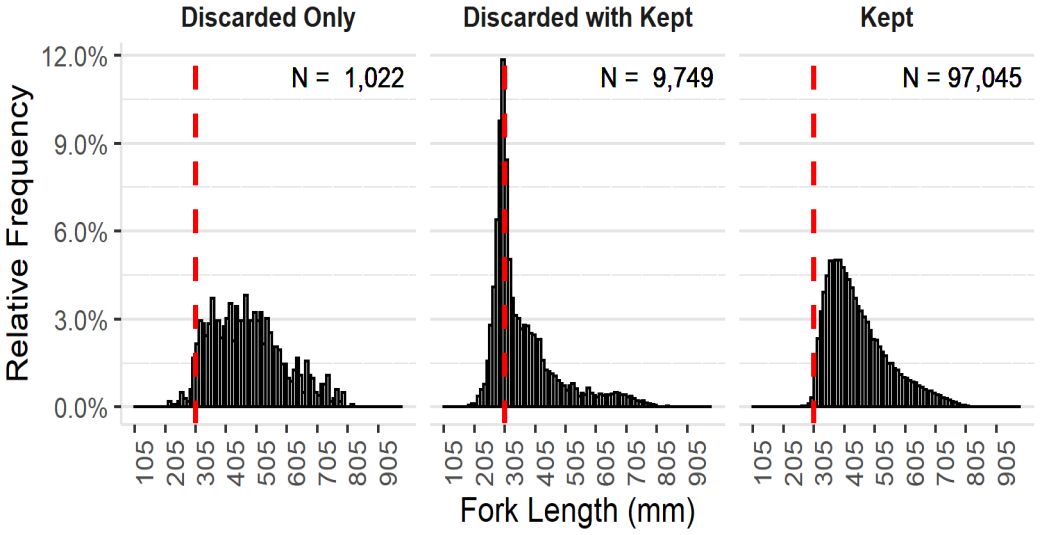


Figure 3. CPUE (catch in whole pounds per hour) time-series for logbook data from 2007 - 2019 for vertical line trips landing GOM Red Snapper.

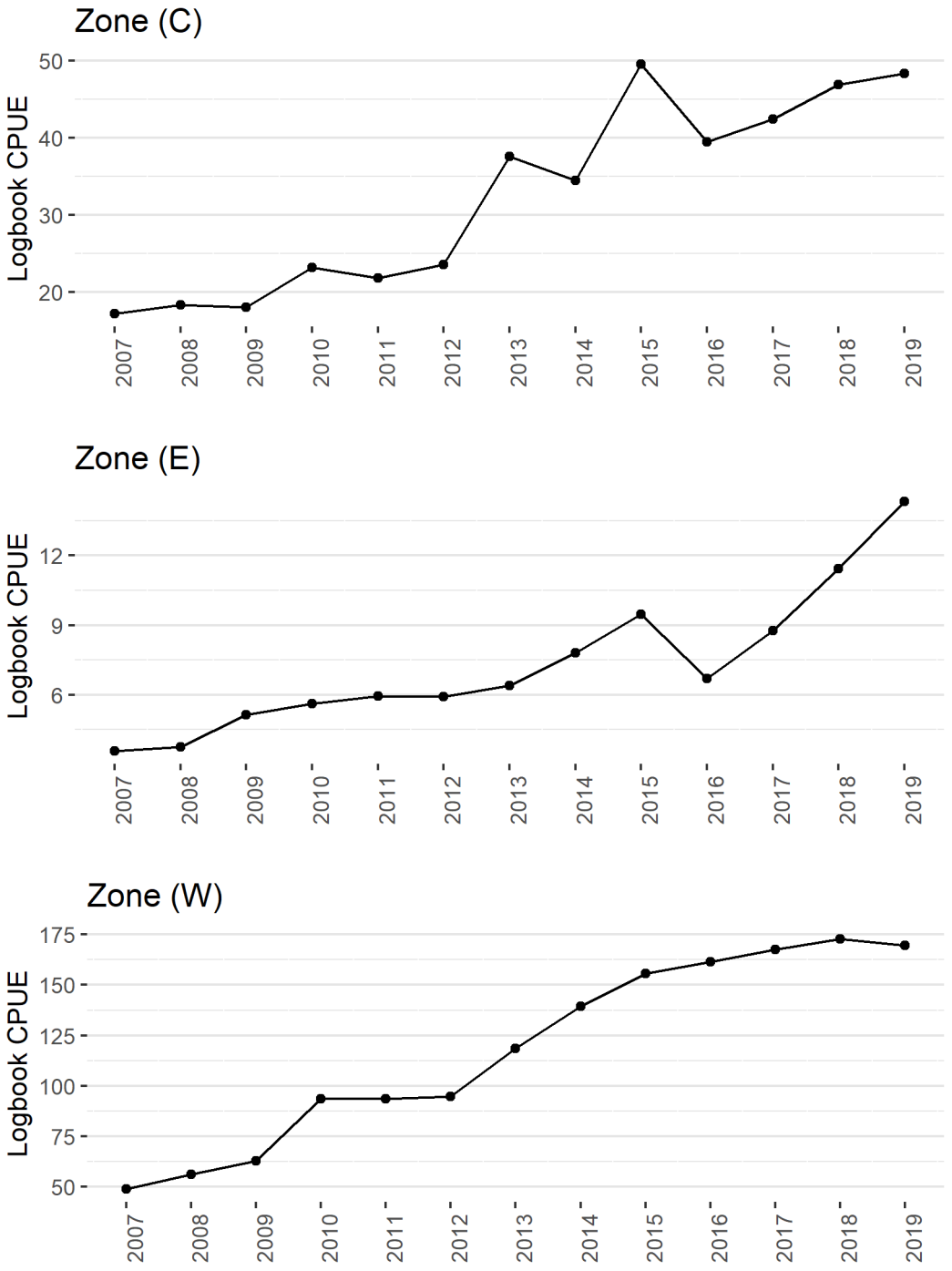


Figure 4. Comparison of vertical line reported annual logbook landings of GOM Red Snapper (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

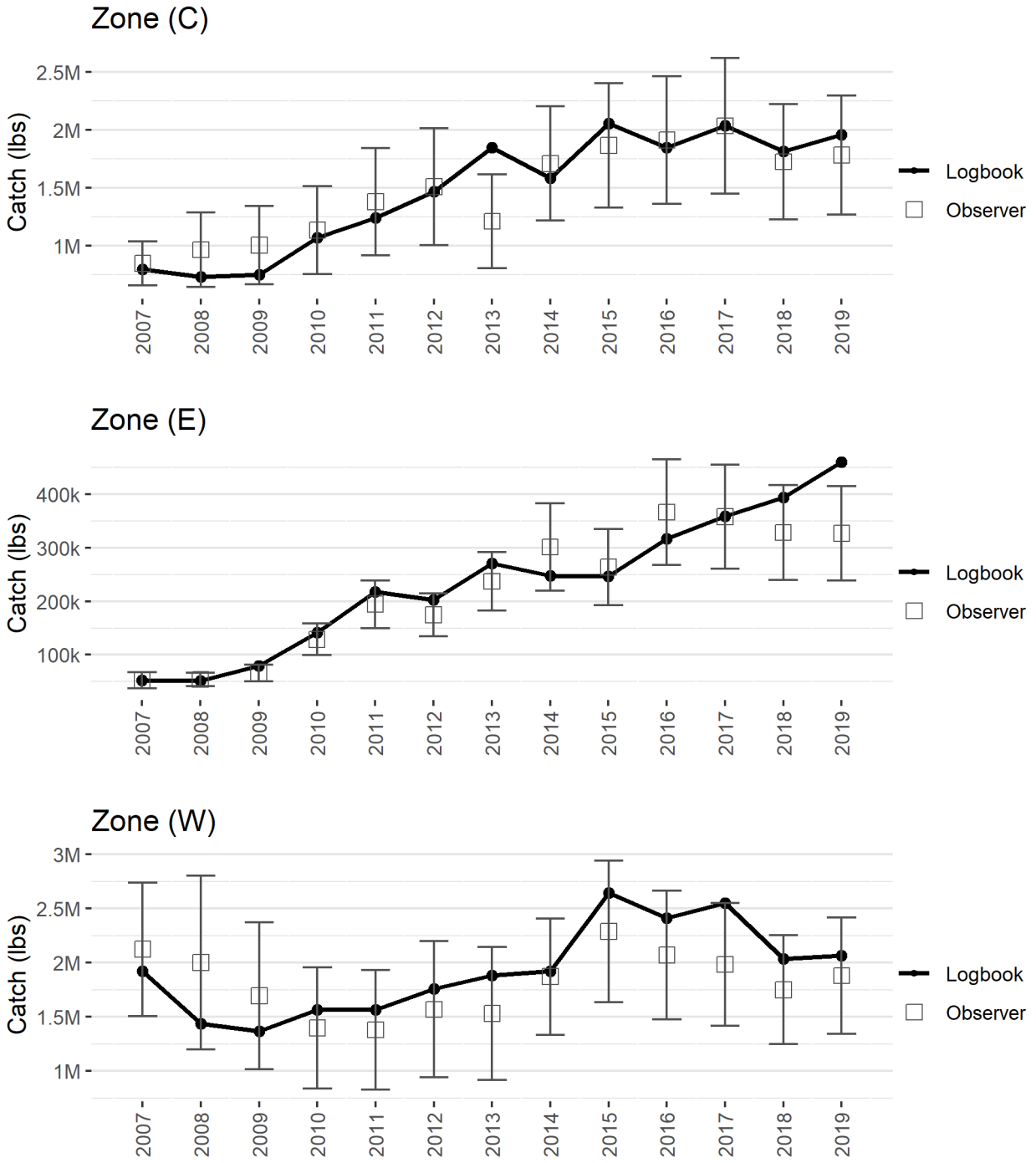
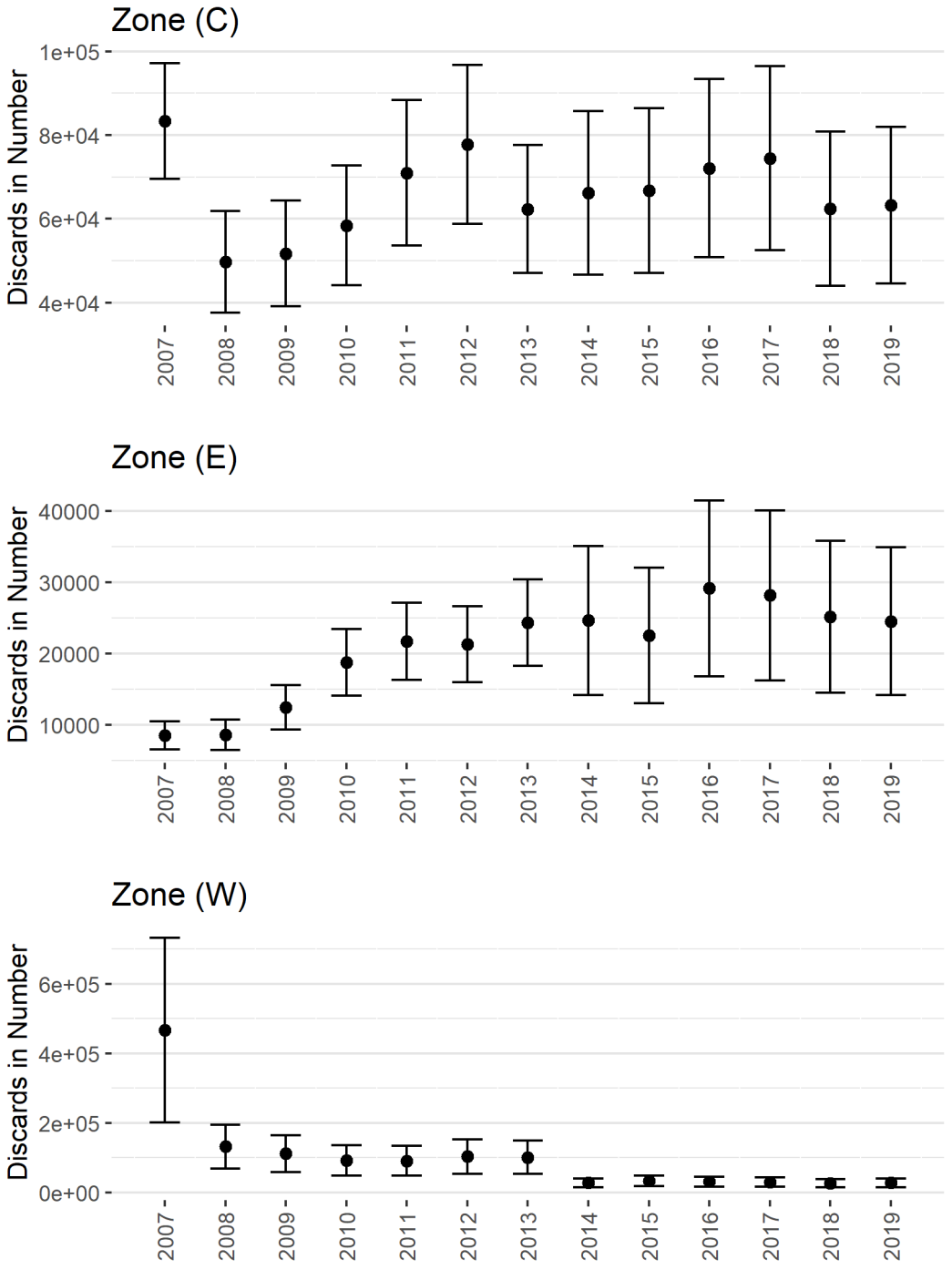


Figure 5. Observer CPUE expansion estimates of GOM Red Snapper vertical line annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 2007 - 2019.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch

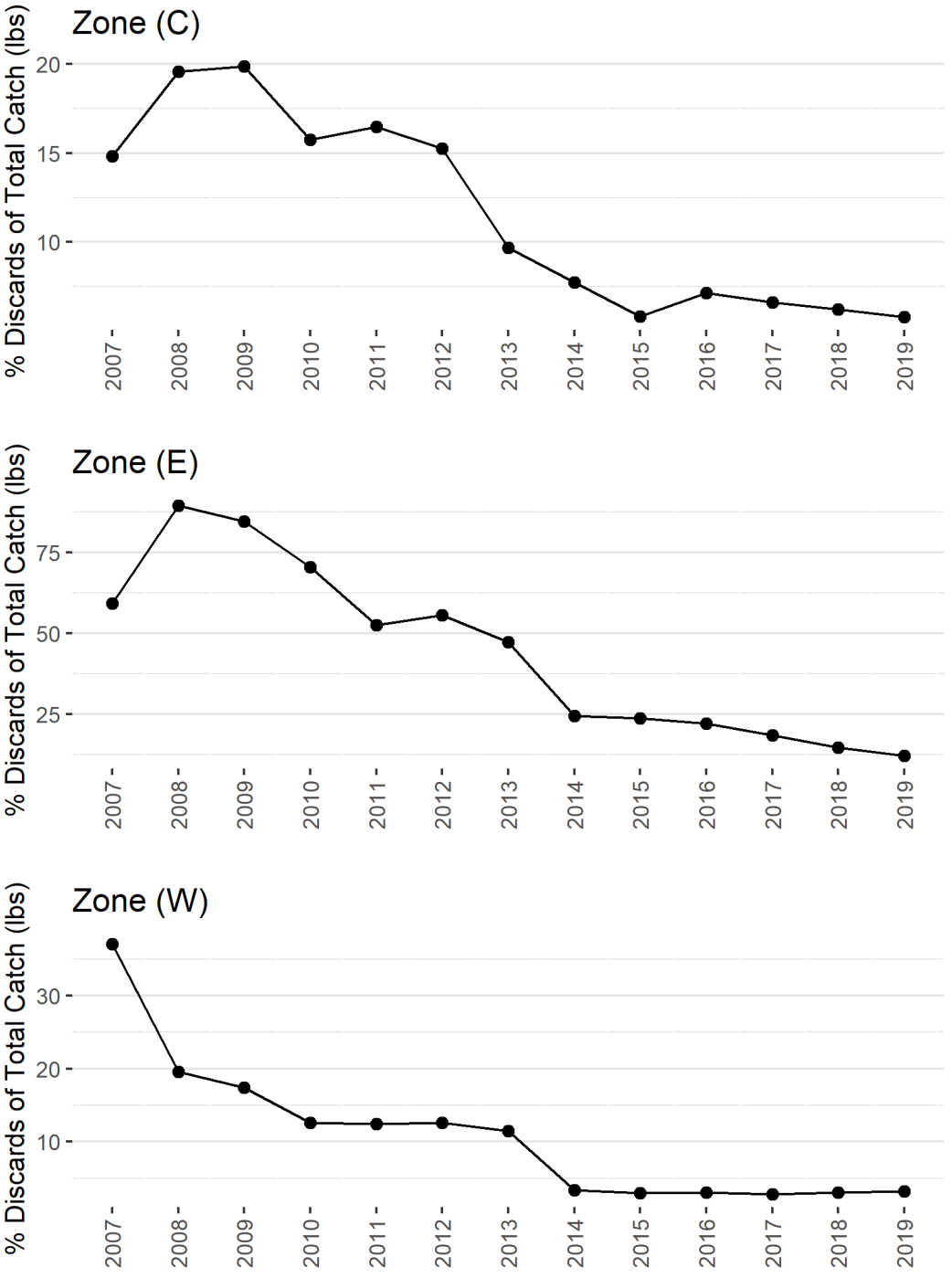


Figure 6. Length-frequency plots of observer bottom longline GOM Red Snapper by disposition (Kept or Discard) and management regime. “Discarded Only” were discards from trips with no kept Red Snapper; “Discarded with Kept” were discards from trips with kept Red Snapper. Vertical dashed lines denote the minimum size limit in fork length (FL) with the red line representing the current size limit (12”); N is the number of measured fish.

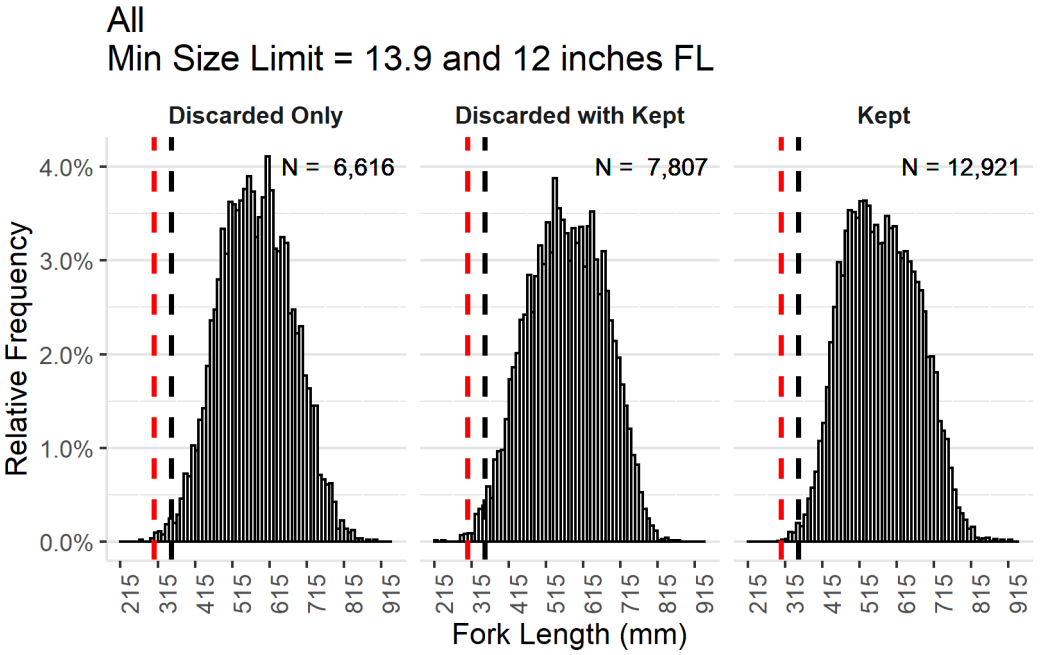
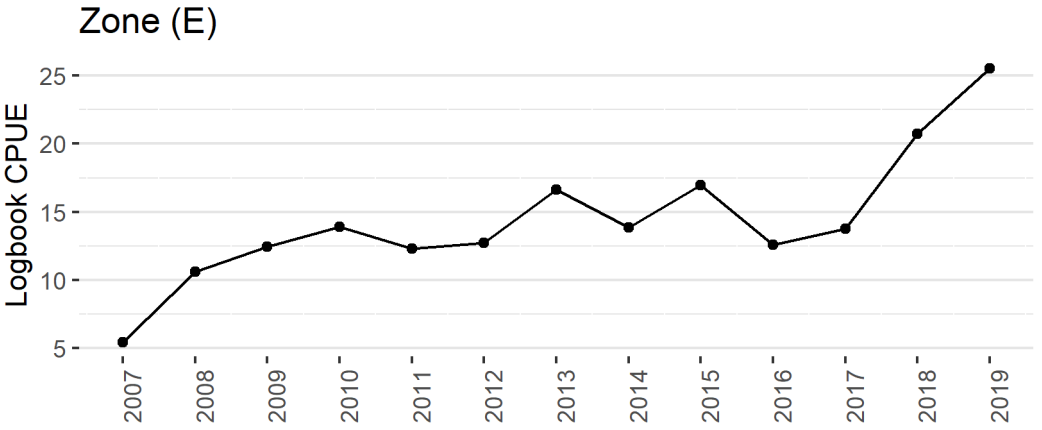


Figure 7. CPUE (catch in whole pounds per hour) time-series for logbook data from 2007 - 2019 for bottom longline trips landing GOM Red Snapper.



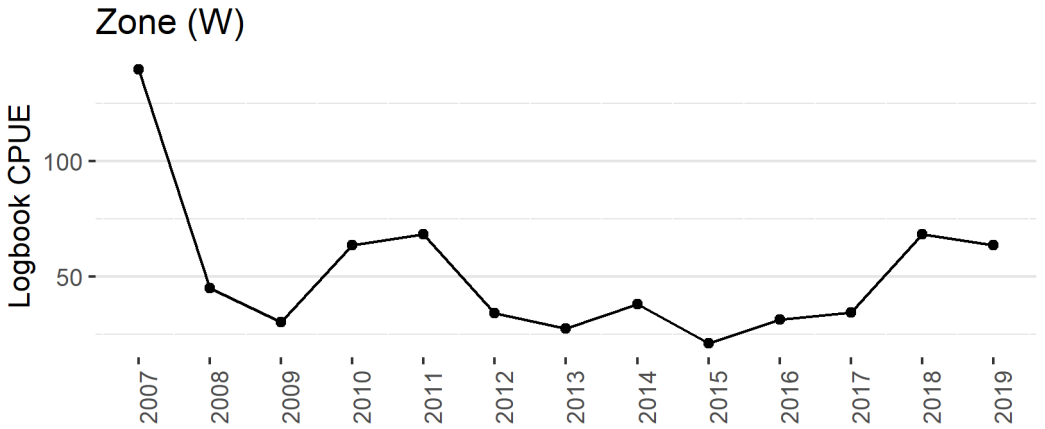


Figure 8. Comparison of bottom longline reported annual logbook landings of GOM Red Snapper (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

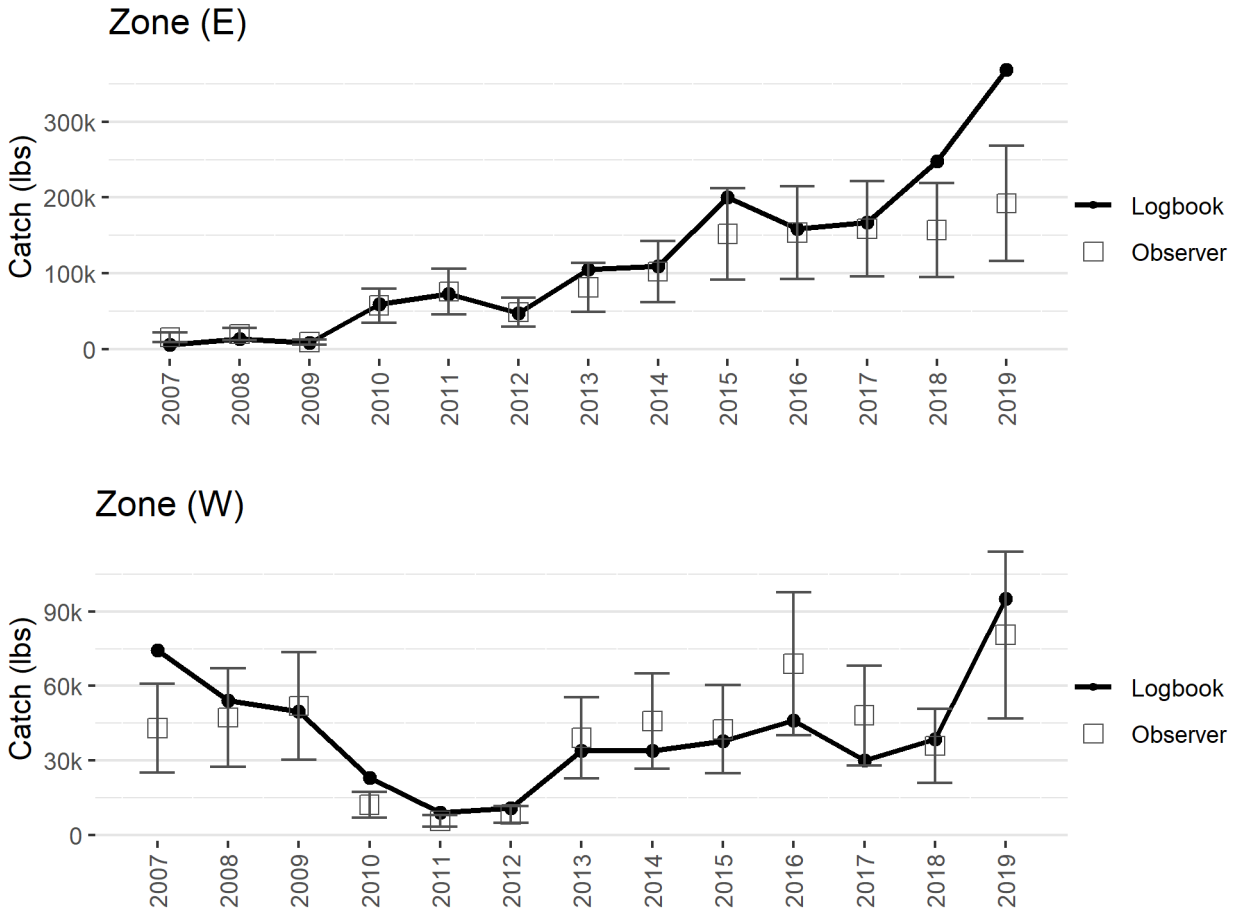
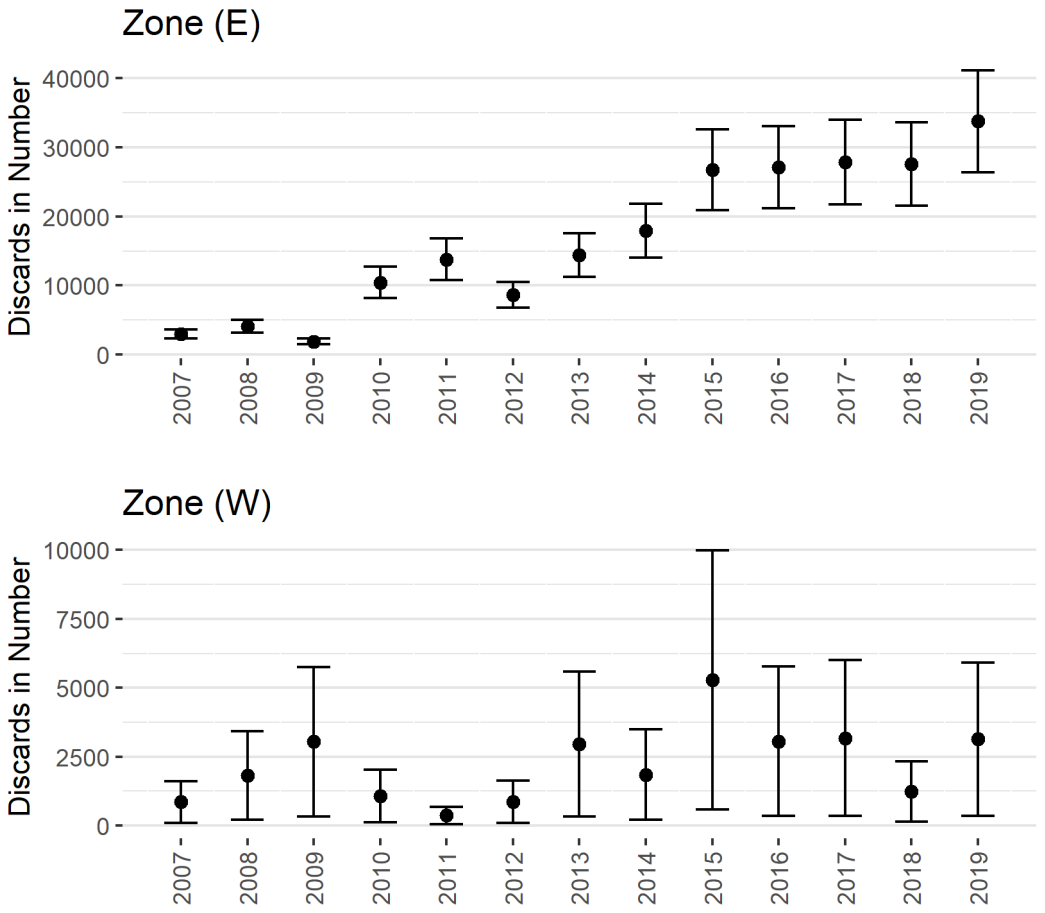
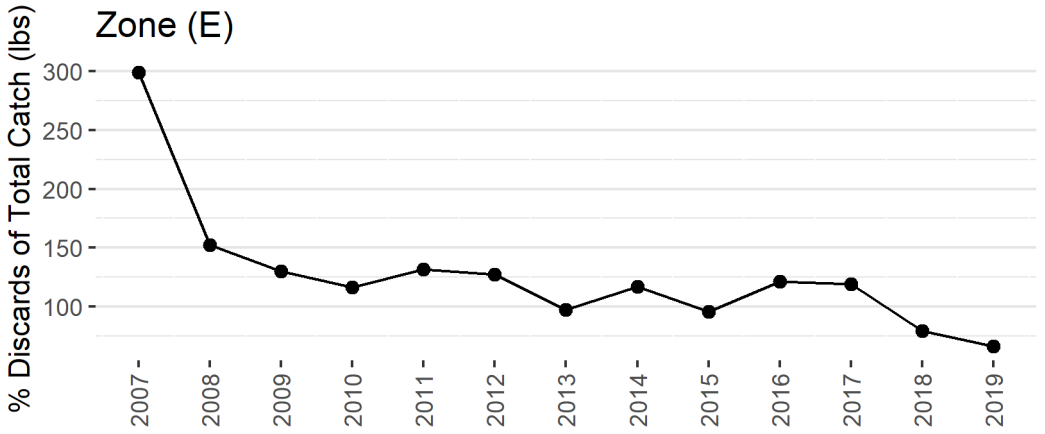


Figure 9. Observer CPUE expansion estimates of GOM Red Snapper bottom longline annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 2007 - 2019.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch



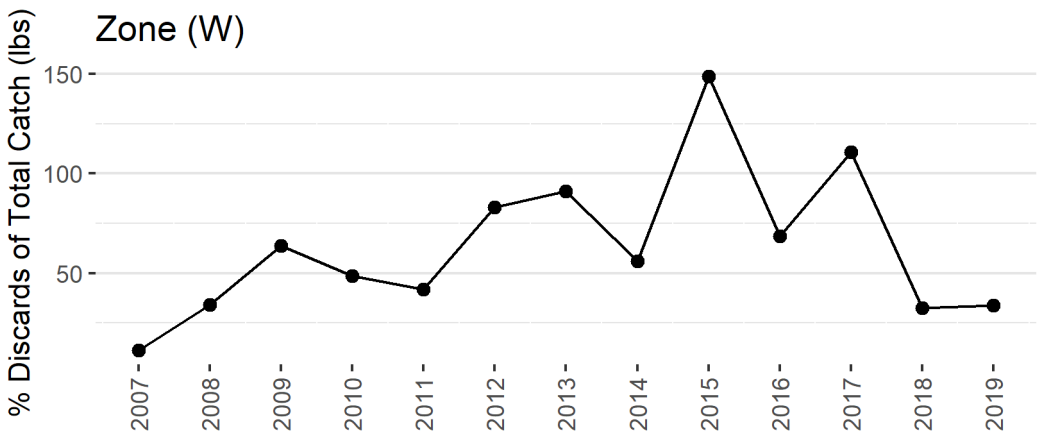


Figure 10. CPUE (catch in whole pounds per hour) time-series for logbook data from 2007 - 2019 for bottom longline trips landing for Central Zone GOM Red Snapper.

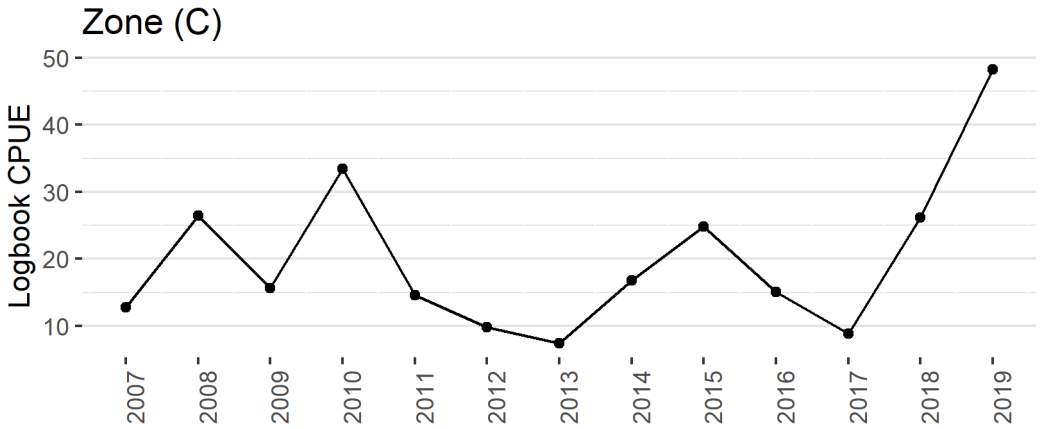
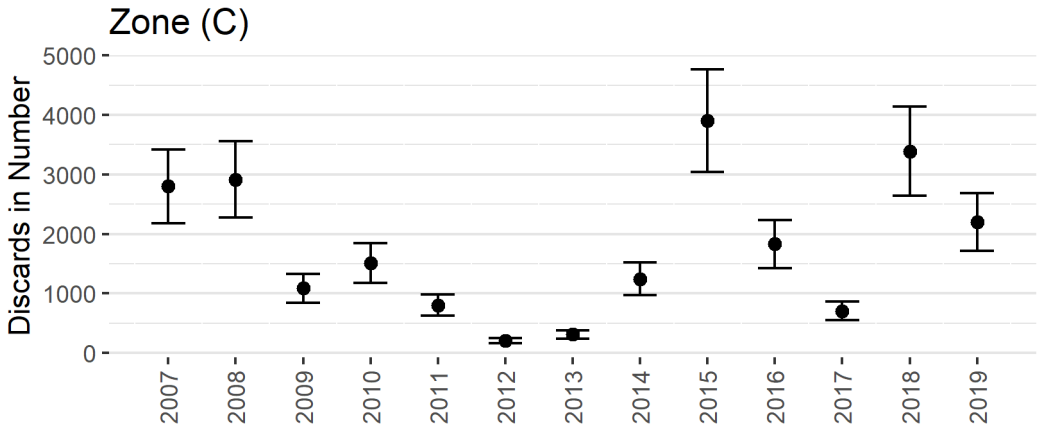


Figure 11. Observer CPUE expansion estimates for Central Zone of GOM Red Snapper bottom longline annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 2007 - 2019.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch