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CPUE Expansion Estimation for Commercial Discards of Gulf of Mexico Yellowedge Grouper (*Hyporthodus flavolimbatus*)

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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 Yellowedge Grouper.

Methods

Data Sources

Catch per unit effort was determined from two commercial observer data sources in which scientific observers on commercial fishing vessels recorded detailed information on catch and effort for a subset of trips. The Reef Fish Observer Program (RFOP) target 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) (Atkinson et al. 2021a, Scott-Denton et al. 2011). The Shark Bottom Longline Observer Program (SBLOP) is responsible for collecting data of the shark bottom longline fishery in the Gulf of Mexico and South Atlantic (Decossas & Mathers 2023). Due to the limited vessels within the shark bottom longline fishery, observers also board vessels that are targeting reef fish species with bottom longline gear under a different permit. For discard estimation, only trips selected under the SBLOP that went on reef fish trips were included in analyses.

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 RFOP began in July 2006; for GOM Yellowedge Grouper discard estimation, complete calendars years 2007-2021 were used. Time periods for the methodology can be defined in terms of the observer programs, 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 Fisheries Logbook Program in which fishers reported basic information on effort and catch by species for every trip (Atkinson et al. 2021b). The coastal logbook program began in 1990 for a subset of vessels in the GOM, and expanded to all vessels in 1993; for GOM Yellowedge Grouper discard estimation, complete calendar years 1993-2021 were considered.

Spatial Domain

Per recommendation of the stock assessment analysts, discard estimates were conducted for the GOM, defined as fishing areas 1-21 (Figure 1). Discard estimates of Yellowedge Grouper were further calculated for the eastern zone (1-12) and western zone (13-21) separately.

Relevant Management History of GOM Yellowedge Grouper

There were two key management changes relevant to discard estimation. (1) Closures beginning in 2004 that started anywhere between May-July of a given year. The fishery would remain closed until the end of the year. (2) The implementation in 2010 of an Individual Fisheries Quota for the GOM deep-water grouper aggregate comprised of four species—Snowy Grouper, Speckled Hind, Warsaw Grouper, and Yellowedge Grouper. There is no minimum size limit regulation for Yellowedge Grouper.

Gear

In the coastal observer data Yellowedge Grouper were observed on 7 vertical line trips with discards from 2007-2021. Therefore, discard estimation was conducted for only bottom longline gear.

Trip-Level Catch for Observer Data

Observers collected catch data at a sub-trip level (e.g., a specific set for bottom longline gear), but it was not feasible to sample every set 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 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

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

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

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

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

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

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

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

where the variance of mean CPUE is

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

N is the total number of logbook trips, and sample variance is

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

Standard error of total catch was calculated as

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

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

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

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.

Stratification by Trip Catch or Effort Level

Computations of mean CPUE, total catch, and associated standard errors were generalized to include strata for trip catch and/or effort levels of Yellowedge Grouper. This enabled accurate estimation of total catch (and discards) in cases where observer sampling was not proportional to the fleet with respect to trip catch or effort (Smith et al. 2019a), e.g., observers sampled fewer or more low-catch trips with respect to logbook low-catch trips, etc. Comparisons of observer vs. logbook frequency distributions for trip-level catch, effort, and CPUE were used to delineate strata for trip catch and/or effort levels (e.g., low, moderate, high, etc.).

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 Yellowedge 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. 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.

Discard Length Composition

The length frequency distribution for discards for a given management time frame was computed in the following manner. Average discard CPUE in stratum h was scaled to stratum total effort $\widehat{Y_h}$.

$$\widehat{Y_h} = \overline{CPUE}_h * \hat{X}_h$$

and multiplied by stratum proportion of length L to obtain the stratum total discards $\widehat{Y_h}$ at length L,

$$\hat{Y}(L)_h = \widehat{Y_h} * p(L)_h.$$

These were summed over all strata to obtain the survey frame total $\hat{Y}$ at length L

$$\hat{Y}(L)_{st} = \Sigma_h \hat{Y}(L)_h,$$

and then converted to relative proportion of length L,

$$p(L)_{st} = \frac{\hat{Y}(L)_{st}}{\Sigma_h \widehat{Y_h}} (1)$$

Annual discards-at-length were computed by multiplying eq. (1) and annual estimates of total discards.

Results and Discussion

When combined for the entire Gulf of Mexico from 2007-2021, there were only 7 vertical line observer trips that had reported discards of Yellowedge Grouper (Table 1). For this reason, discards are considered negligible for this gear.

The observer database included 182 Yellowedge Grouper trips from bottom longline vessels with corresponding trip and set information from 2007-2021. Observer sampling effort is summarized in Table 2, distinguishing all trips from the subset of trips that captured Yellowedge Grouper. Discard estimation was conducted separately within the pre-IFQ (2007-2009), early IFQ (2010-2014), and later IFQ (2015-2021) management regimes to account for potential changes in the discard CPUE indicated by differences in the discard length frequencies (Figure 2). While there is no minimum size regulation for Yellowedge Grouper, the data were separated into these management regimes to account for an increased number of smaller fish discarded on a trip that also had kept fish in the early IFQ time period compared to 2015-2021. Observer data from the pre-IFQ period (2007-2009) time period were used for hindcasting discards for the pre-observer years 1993-2006.

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting Yellowedge Grouper showed a difference in CPUE trends between the eastern and western zones of the Gulf of Mexico (Figure 3). In the eastern zone, there was a general increase in CPUE during the pre-IFQ management regime, followed by a decrease during the first year IFQ was implemented in 2010 and then a general stable CPUE from 2010-2021. The western zone shows a peak in 2011 followed by a general decrease in nominal CPUE. Catch-effort data for observer trips catching Yellowedge Grouper were pooled across years for the respective management regimes. Logbook catch-effort data for Yellowedge 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 First (2007-2009), Second (2010-2014), and Third (2015-2021) management regimes.

Observer and logbook frequency distributions of trip-level catch for the pre-IFQ management regime (2007-2009) for both the eastern and western zones showed that observers sampled a higher proportion of high catch Yellowedge Grouper trips relative to the commercial fleet. However, because of the limited observer data in the western zone for this management regime, data for the eastern and western zones were pooled to stratify trips into high catch (> 1,801 lbs.) and low catch (<= 1,801 lbs.) trips for subsequent analysis and estimation. This is highlighted in Table 3A as zone (All) for the first management regime (2007-2009). Additionally, for both IFQ management regimes, catch level stratification was performed for each zone separately to account for the discrepancy in observer sampling relative to the commercial fleet (Table 3). In subsequent analyses, observer and logbook trips were grouped into strata according to low (L) and high (H) catches.

The proportions of observer trips and effort encountering Yellowedge Grouper that had kept fish are given in Table 4 by zone, management regime, and catch level strata. These proportions were used to adjust annual logbook total Yellowedge Grouper trips and effort (Table 5) 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 6. These CPUEs were the basis for expansion

estimates of Yellowedge Grouper catch and discards. Observer discard CPUEs for the pre-IFQ management regime (2007-2009) were the basis for hindcasting discards during 1993-2006.

CPUE expansion estimates of annual total landed catch of GOM Yellowedge Gropuer compared favorably with reported logbook landings for 1993-2021 (Figure 4). In the expansion for the pre-IFQ management regime, the pooled eastern and western CPUE calculated from the observer data was applied to zone specific logbook total effort. CPUE expansion estimates for annual discards in numbers and weight (whole pounds) of GOM Yellowedge Grouper for 1993-2022 are provided in Table 8. Estimated discards in number averaged about 500 fish for 1993-2022 in the eastern zone and 150 fish in the western zone (Figure 5A). Discards in weight accounted for less than 1% of the total catch (kept + discards) during 1993-2022 (Figure 5B). Lastly, annual discard length frequencies were provided in 1 cm fork length bins using the catch and effort strata by management regime (Figure 6).

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

Year	Total Trips	Yellowedge Grouper Trips	Yellowedge Grouper Trips with Discards
2007	97	10	4
2008	53	5	1
2009	46	1	0
2010	56	1	0
2011	105	5	0
2012	254	17	3
2013	125	3	0
2014	109	4	0
2015	201	11	0
2016	142	8	0
2017	67	3	0
2018	39	3	0
2019	30	3	0
2020	20	0	0
2021	41	1	0

Table 2. Number of total and Yellowedge Grouper (YEG) coastal observer bottom longline trips by year for the GOM.

	Eastern Zone		Western Zone	
Year	Total Trips	YEG Trips	Total Trips	YEG Trips
2007	19	4	0	0
2008	3	1	2	2
2009	33	18	4	4
2010	65	26	7	7
2011	86	22	5	4
2012	36	9	4	3
2013	79	25	3	2
2014	26	7	1	1
2015	24	7	2	2
2016	51	8	8	8
2017	19	7	2	2
2018	5	0	0	0
2019	7	3	0	0
2020	2	2	1	1
2021	9	6	1	1

Table 3. Definition of trip catch level strata for GOM Yellowedge Grouper, and corresponding percentages of logbook and observer bottom longline trips for each zone and management regime. Tables separated into (A) First management regime (2007-2009) for the entire Gulf of Mexico, (B) Second management regime (2010-2014) for the eastern zone, (C) Third management regime (2015-2021) for the eastern zone, (D) Second management regime (2010-2014) for the western zone, and (E) Third management regime (2015-2021) for the western zone.

(A) Zone (All) Management Regime (First 2007-2009)

Management Regime	Season	Strata Level	Stratum Code	% Trips	
				Logbook	Observer
First 2007-2009	Open	Low, Catch <= 1801 lbs	L	46.4	24.1
First 2007-2009	Open	High, Catch > 1801 lbs	H	53.6	75.9

(B) Zone (East) Management Regime (Second 2010-2014)

Management Regime	Season	Strata Level	Stratum Code	% Trips	
				Logbook	Observer
Second 2010-2014	Open	Low, Catch <= 2138 lbs	L	54.1	57.3
Second 2010-2014	Open	High, Catch > 2138 lbs	H	45.9	42.7

(C) Zone (East) Management Regime (Third 2015-2021)

Management Regime	Season	Strata Level	Stratum Code	% Trips	
				Logbook	Observer
Third 2015-2021	Open	Low, Catch <= 1563 lbs	L	47	33.3
Third 2015-2021	Open	High, Catch > 1563 lbs	H	53	66.7

(D) Zone (West) Management Regime (Second 2010-2014)

Management Regime	Season	Strata Level	Stratum Code	% Trips	
				Logbook	Observer
Second 2010-2014	Open	Low, Catch <= 5790 lbs	L	75.3	76.5
Second 2010-2014	Open	High, Catch > 5790 lbs	H	24.7	23.5

(E) Zone (West) Management Regime (Third 2015-2021)

Management Regime	Season	Strata Level	% Trips		
			Stratum Code	Logbook	Observer
Third 2015-2021	Open	Low, Catch <= 2813 lbs	L	49.9	21.4
Third 2015-2021	Open	High, Catch > 2813 lbs	H	50.1	78.6

Table 4. Yellowedge Grouper bottom longline trip and effort adjustment factors by management regime and catch level strata in GOM. Catch level strata are defined in Table 3. The proportions of Yellowedge Grouper observer trips and effort with kept Yellowedge Grouper were used to respectively adjust annual logbook total trips and effort (Table 5) to account for logbook trips that only had discarded fish. Tables separated into (A) Entire Gulf of Mexico, (B) Eastern zone, and (C) Western zone.

(A) Zone (All)

Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Yellowedge Grouper	
					Trips	Effort
First 2007-2009	Open	Catch	L	7	1	1
First 2007-2009	Open	Catch	H	22	1	1

(B) Zone (East)

Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Yellowedge Grouper	
					Trips	Effort
Second 2010-2014	Open	Catch	L	51	0.902	0.901
Second 2010-2014	Open	Catch	H	38	1	1
Third 2015-2021	Open	Catch	L	11	0.818	0.762
Third 2015-2021	Open	Catch	H	22	1	1

(C) Zone (West)

Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Yellowedge Grouper	
					Trips	Effort
Second 2010-2014	Open	Catch	L	13	1	1
Second 2010-2014	Open	Catch	H	4	1	1
Third 2015-2021	Open	Catch	L	3	1	1
Third 2015-2021	Open	Catch	H	11	1	1

Table 5. Annual time-series of bottom longline logbook trips (number) and effort (hours) by catch level strata for GOM Yellowedge Grouper separated into (A) East and (B) West zones.

(A) Zone (East)

Year	Season	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
				Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
1993	Open	Catch	H	39	39	1,514	1,514
1993	Open	Catch	L	140	140	4,163	4,163
1994	Open	Catch	H	122	122	4,650	4,650
1994	Open	Catch	L	217	217	5,396	5,396
1995	Open	Catch	H	78	78	2,702	2,702
1995	Open	Catch	L	221	221	4,879	4,879
1996	Open	Catch	H	63	63	2,406	2,406
1996	Open	Catch	L	244	244	5,311	5,311
1997	Open	Catch	H	141	141	4,873	4,873
1997	Open	Catch	L	315	315	7,384	7,384
1998	Open	Catch	H	88	88	2,868	2,868
1998	Open	Catch	L	269	269	5,516	5,516
1999	Open	Catch	H	79	79	2,340	2,340
1999	Open	Catch	L	268	268	5,735	5,735
2000	Open	Catch	H	167	167	5,365	5,365
2000	Open	Catch	L	316	316	6,085	6,085
2001	Open	Catch	H	129	129	3,411	3,411

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2001	Open	Catch	L	340	340	6,713	6,713
2002	Open	Catch	H	77	77	1,886	1,886
2002	Open	Catch	L	315	315	5,584	5,584
2003	Open	Catch	H	139	139	3,731	3,731
2003	Open	Catch	L	335	335	5,878	5,878
2004	Open	Catch	H	132	132	3,335	3,335
2004	Open	Catch	L	184	184	3,224	3,224
2005	Open	Catch	H	95	95	2,094	2,094
2005	Open	Catch	L	183	183	2,761	2,761
2006	Open	Catch	H	128	128	2,428	2,428
2006	Open	Catch	L	187	187	2,736	2,736
2007	Open	Catch	H	171	171	3,754	3,754
2007	Open	Catch	L	165	165	2,789	2,789
2008	Open	Catch	H	162	162	3,344	3,344
2008	Open	Catch	L	139	139	2,312	2,312
2009	Open	Catch	H	140	140	3,315	3,315
2009	Open	Catch	L	169	169	2,969	2,969
2010	Open	Catch	H	60	60	1,798	1,798
2010	Open	Catch	L	80	89	1,762	1,956
2011	Open	Catch	H	66	66	2,144	2,144
2011	Open	Catch	L	97	108	2,386	2,648
2012	Open	Catch	H	91	91	2,512	2,512
2012	Open	Catch	L	111	123	2,436	2,704
2013	Open	Catch	H	88	88	2,409	2,409
2013	Open	Catch	L	79	88	1,940	2,153
2014	Open	Catch	H	94	94	2,738	2,738
2014	Open	Catch	L	103	114	2,855	3,169
2015	Open	Catch	H	104	104	3,220	3,220
2015	Open	Catch	L	97	119	2,893	3,795
2016	Open	Catch	H	84	84	2,474	2,474
2016	Open	Catch	L	92	112	2,297	3,013
2017	Open	Catch	H	93	93	2,966	2,966
2017	Open	Catch	L	78	95	2,044	2,681
2018	Open	Catch	H	117	117	4,257	4,257
2018	Open	Catch	L	77	94	1,881	2,467

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2019	Open	Catch	H	126	126	4,389	4,389
2019	Open	Catch	L	102	125	2,802	3,675
2020	Open	Catch	H	117	117	3,530	3,530
2020	Open	Catch	L	112	137	2,367	3,105
2021	Open	Catch	H	129	129	4,010	4,010
2021	Open	Catch	L	125	153	2,634	3,455

(B) Zone (West)

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
1993	Open	Catch	H	41	41	1,431	1,431
1993	Open	Catch	L	75	75	1,606	1,606
1994	Open	Catch	H	57	57	1,773	1,773
1994	Open	Catch	L	43	43	738	738
1995	Open	Catch	H	66	66	2,458	2,458
1995	Open	Catch	L	112	112	1,891	1,891
1996	Open	Catch	H	42	42	1,536	1,536
1996	Open	Catch	L	87	87	1,617	1,617
1997	Open	Catch	H	44	44	1,626	1,626
1997	Open	Catch	L	51	51	843	843
1998	Open	Catch	H	50	50	1,881	1,881
1998	Open	Catch	L	40	40	637	637
1999	Open	Catch	H	76	76	2,933	2,933
1999	Open	Catch	L	84	84	1,426	1,426
2000	Open	Catch	H	61	61	2,313	2,313
2000	Open	Catch	L	97	97	1,388	1,388
2001	Open	Catch	H	29	29	987	987
2001	Open	Catch	L	90	90	1,064	1,064
2002	Open	Catch	H	43	43	1,381	1,381
2002	Open	Catch	L	104	104	1,641	1,641
2003	Open	Catch	H	79	79	2,893	2,893
2003	Open	Catch	L	67	67	1,318	1,318
2004	Open	Catch	H	51	51	2,070	2,070

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2004	Open	Catch	L	49	49	538	538
2005	Open	Catch	H	46	46	1,361	1,361
2005	Open	Catch	L	53	53	697	697
2006	Open	Catch	H	46	46	1,563	1,563
2006	Open	Catch	L	37	37	424	424
2007	Open	Catch	H	29	29	922	922
2007	Open	Catch	L	20	20	504	504
2008	Open	Catch	H	40	40	1,290	1,290
2008	Open	Catch	L	11	11	237	237
2009	Open	Catch	H	50	50	1,921	1,921
2009	Open	Catch	L	9	9	237	237
2010	Open	Catch	H	5	5	126	126
2010	Open	Catch	L	41	41	961	961
2011	Open	Catch	H	9	9	276	276
2011	Open	Catch	L	40	40	794	794
2012	Open	Catch	H	8	8	336	336
2012	Open	Catch	L	25	25	565	565
2013	Open	Catch	H	13	13	743	743
2013	Open	Catch	L	31	31	968	968
2014	Open	Catch	H	14	14	927	927
2014	Open	Catch	L	12	12	309	309
2015	Open	Catch	H	19	19	1,009	1,009
2015	Open	Catch	L	15	15	594	594
2016	Open	Catch	H	31	31	1,935	1,935
2016	Open	Catch	L	22	22	830	830
2017	Open	Catch	H	27	27	1,765	1,765
2017	Open	Catch	L	27	27	1,061	1,061
2018	Open	Catch	H	28	28	1,920	1,920
2018	Open	Catch	L	24	24	513	513
2019	Open	Catch	H	35	35	2,392	2,392
2019	Open	Catch	L	37	37	1,170	1,170
2020	Open	Catch	H	30	30	1,515	1,515
2020	Open	Catch	L	24	24	655	655
2021	Open	Catch	H	14	14	791	791
2021	Open	Catch	L	34	34	832	832

Table 6. Estimated observer mean CPUE in weight by management regime and catch level strata for expansion estimates of bottom longline GOM Yellowedge Grouper catch and discards. Tables separated into (A) Entire Gulf of Mexico, (B) Eastern zone, and (C) Western zone.

(A) Zone (All)

					Observer CPUE	
Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Kept	Discard
First 2007-2009	Open	Catch	L	43.011	44.412	0.022
First 2007-2009	Open	Catch	H	147.503	144.177	0.526

(B) Zone (East)

					Observer CPUE	
Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Kept	Discard
Second 2010-2014	Open	Catch	L	30.664	23.079	0.274
Second 2010-2014	Open	Catch	H	146.432	133.508	0.747
Third 2015-2021	Open	Catch	L	17.780	16.523	0.023
Third 2015-2021	Open	Catch	H	120.735	136.627	0.846

(C) Zone (West)

					Observer CPUE	
Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Kept	Discard
Second 2010-2014	Open	Catch	L	126.757	86.919	0.559
Second 2010-2014	Open	Catch	H	164.659	203.055	0.924
Third 2015-2021	Open	Catch	L	40.925	28.776	0.023
Third 2015-2021	Open	Catch	H	91.862	110.057	0.535

Table 7. Time-series of CPUE expansion estimates for GOM Yellowedge Grouper bottom longline discards in weight (lbs.) and number (with associated standard errors). Discards separated into (A) Eastern and (B) Western zones.

(A) Zone (East)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
1993	647	274	133	36
1994	1,696	732	336	96
1995	1,153	489	237	65
1996	880	368	186	49
1997	2,181	933	440	123
1998	1,280	544	262	72
1999	1,264	529	267	71
2000	2,563	1,104	510	145
2001	1,779	754	366	100
2002	998	401	228	56
2003	1,973	830	413	110
2004	1,908	829	372	108
2005	1,396	597	282	79
2006	1,667	718	332	94
2007	2,036	912	397	127
2008	1,810	811	352	112
2009	1,809	811	358	114
2010	1,878	1,114	428	178
2011	2,326	1,379	523	218
2012	2,616	1,551	596	249
2013	2,388	1,416	554	231
2014	2,912	1,727	659	275
2015	2,809	1,258	739	303
2016	2,160	968	569	233
2017	2,569	1,151	669	274
2018	3,656	1,638	940	385
2019	3,794	1,700	985	404
2020	3,055	1,369	795	326
2021	3,469	1,554	902	369

(B) Zone (West)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
1993	672	288	135	38
1994	872	383	166	50
1995	1,128	486	224	64
1996	694	298	139	39
1997	689	300	134	39
1998	955	421	181	55
1999	1,431	629	272	82
2000	887	385	174	50
2001	413	172	88	23
2002	767	331	152	43
2003	1,341	590	255	77
2004	1,023	450	195	59
2005	855	371	167	49
2006	784	345	149	45
2007	496	222	95	30
2008	684	306	127	41
2009	1,015	455	187	60
2010	653	407	114	72
2011	699	436	150	94
2012	626	390	152	96
2013	1,227	765	316	198
2014	1,029	642	326	204
2015	553	285	106	42
2016	1,054	543	194	76
2017	969	499	186	73
2018	1,039	535	183	72
2019	1,307	673	244	96
2020	826	425	152	60
2021	442	228	94	37

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

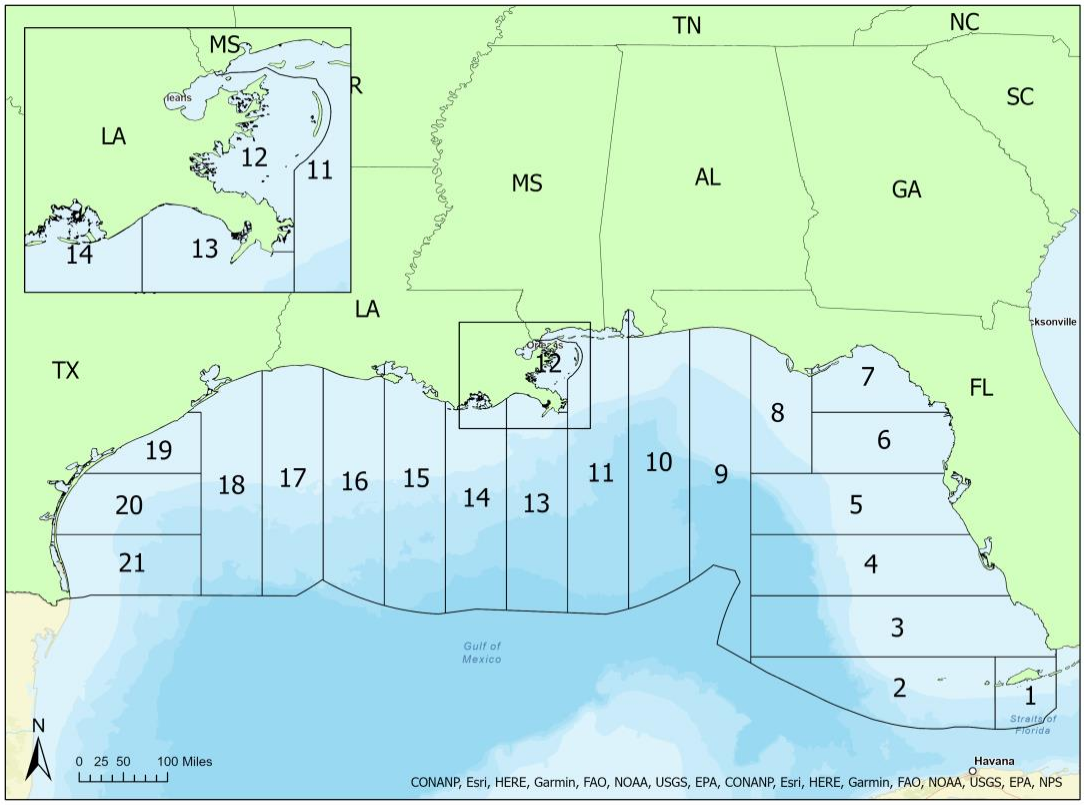
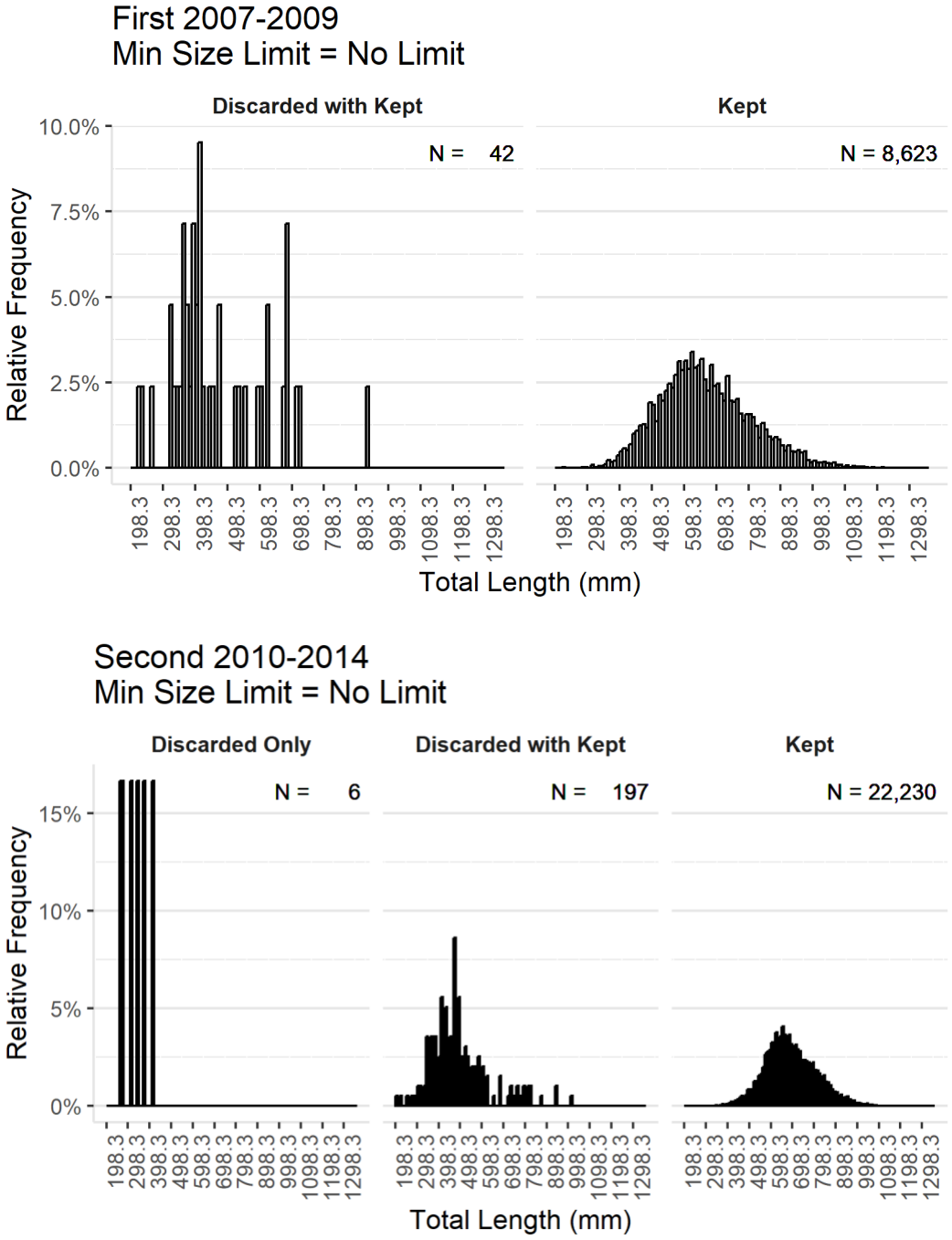


Figure 2. Length-frequency plots of observer bottom longline GOM Yellowedge Grouper by disposition (Kept or Discard) and management regime. "Discarded Only" were discards from trips with no kept Yellowedge Grouper; "Discarded with Kept" were discards from trips with kept Yellowedge Grouper. N is the number of measured fish.



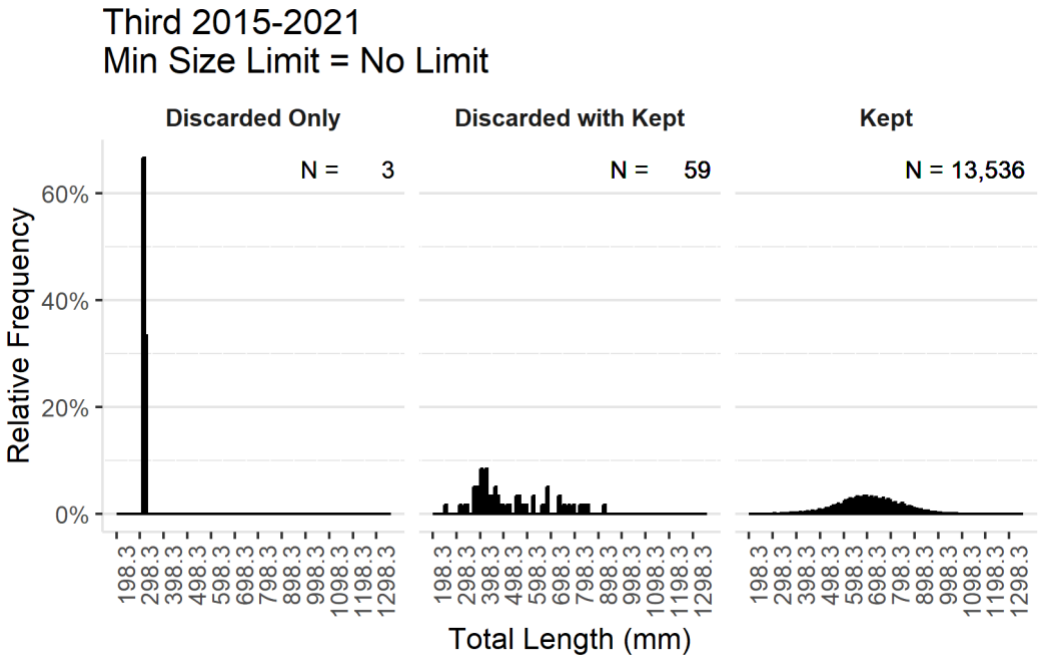

Third 2015-2021
Min Size Limit = No Limit
Discarded Only
Discarded with Kept
Kept
N = 3
N = 59
N = 13,536
Relative Frequency
60%
40%
20%
0%
198.3
298.3
398.3
498.3
598.3
698.3
798.3
898.3
998.3
1098.3
1198.3
1298.3
Total Length (mm)

Figure 3. CPUE (catch in whole pounds per hour) time-series for logbook data from 1993 - 2021 for bottom longline trips landing GOM Yellowedge Grouper. The observer time period is from 2007 - 2021.

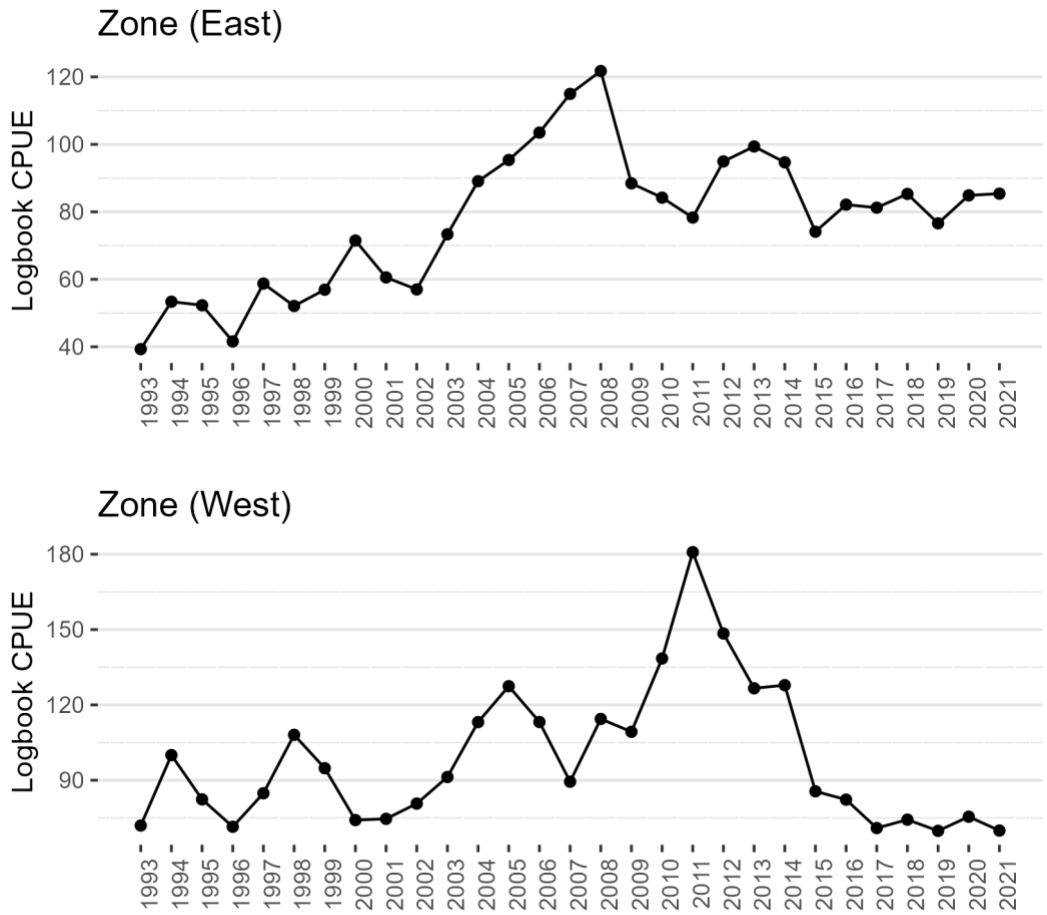


Figure 4. Comparison of bottom longline reported annual logbook landings of GOM Yellowedge Grouper (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

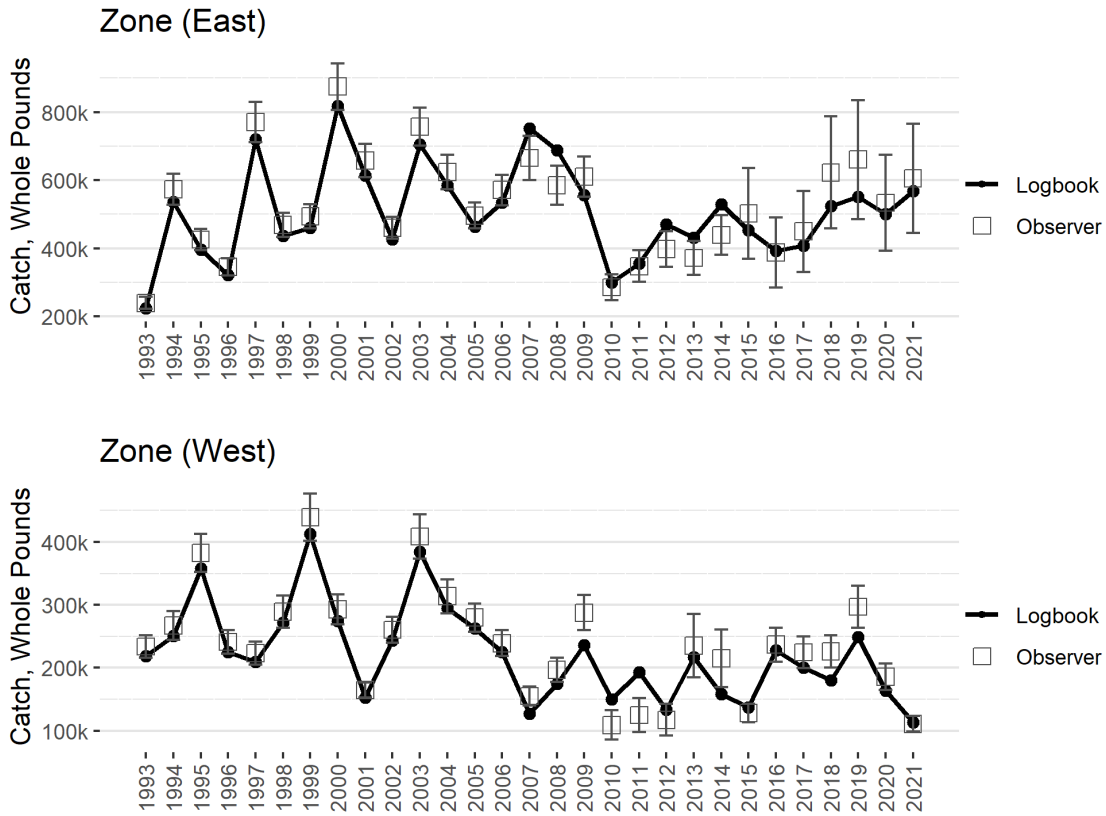
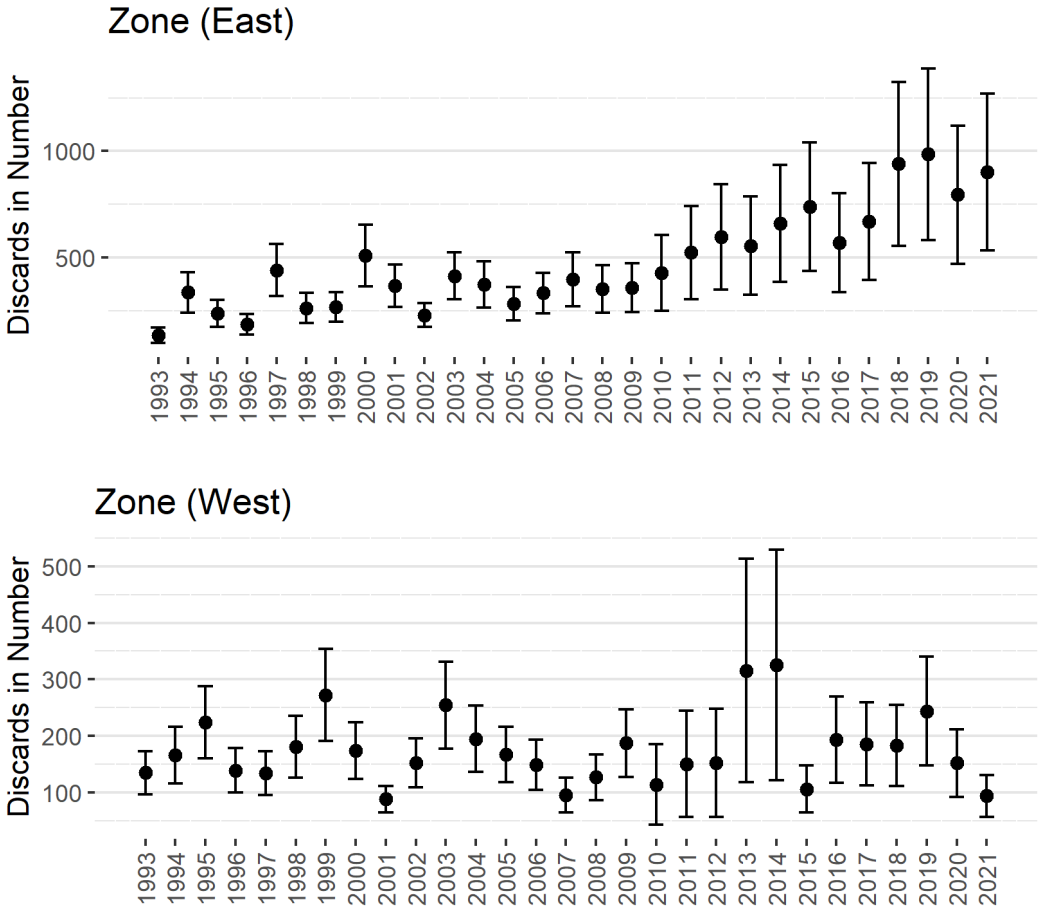


Figure 5. Observer CPUE expansion estimates of GOM Yellowedge Grouper bottom longline annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 2007 - 2021.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch

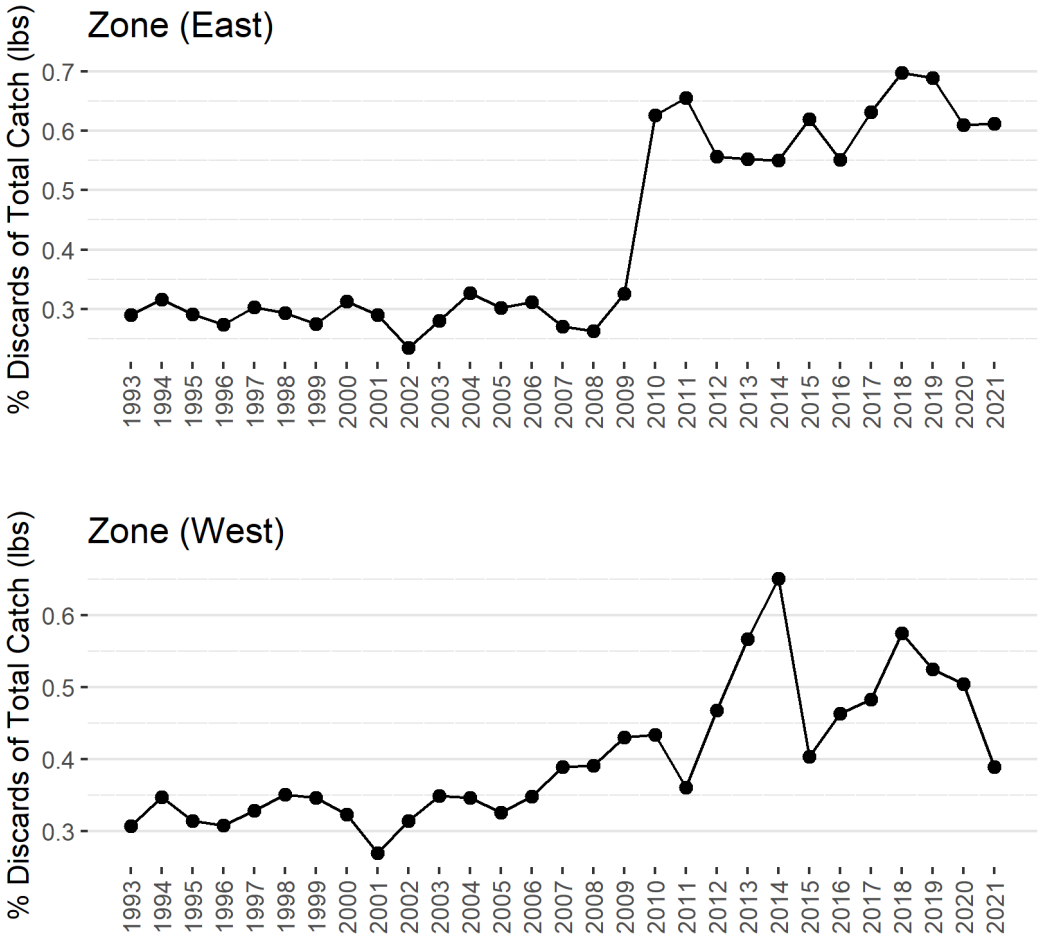
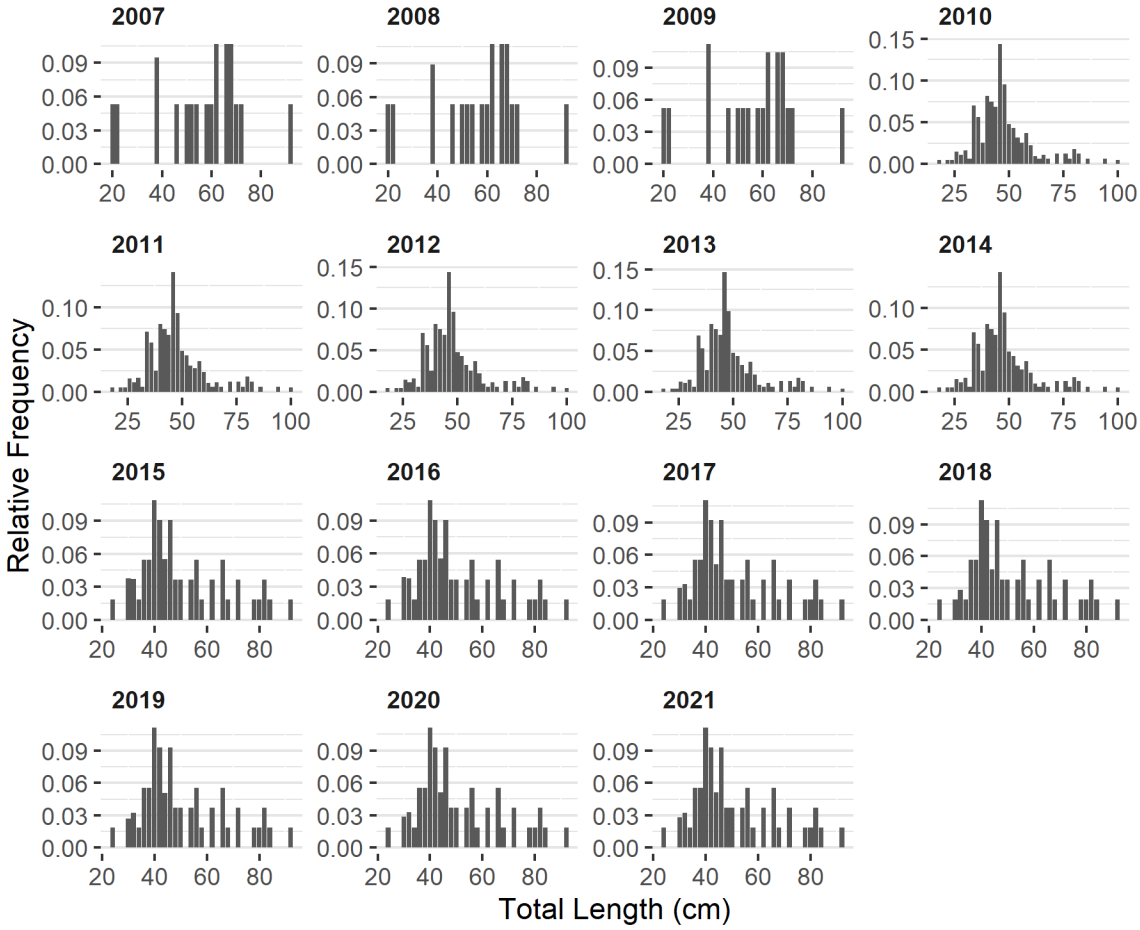
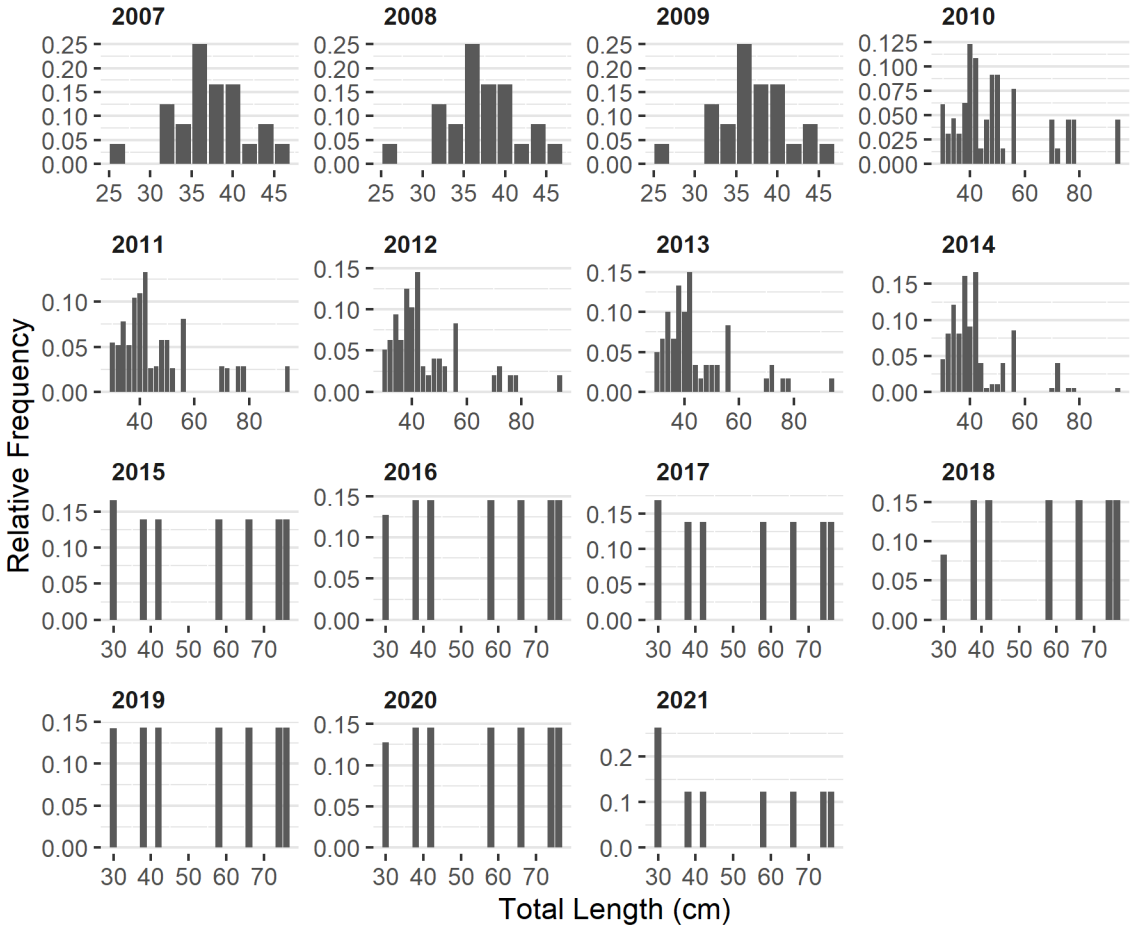


Figure 6. Commercial annual discard length compositions for GOM Yellowedge Grouper, accounting for catch and effort level stratification by management period.

(A) Zone (East)



(B) Zone (West)


2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Relative Frequency
Total Length (cm)