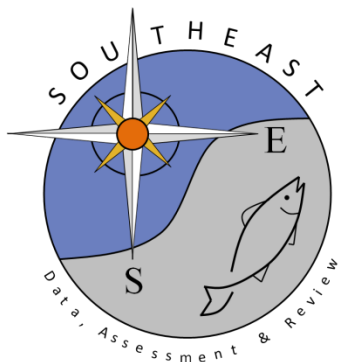


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CPUE Expansion Estimation for Commercial Discards of Gulf of America Gray Triggerfish

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Introduction

The general approach for estimating discards for the commercial reef fish fleet 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 and length composition methods developed and recommended since SEDAR 61 (Gulf of America Red Grouper in SEDAR Working Paper 61-15; Smith et al. 2018).

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 America 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 Gulf of America Gray Triggerfish discard estimation, complete calendar years 2007-2024 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 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 Florida and expanded to all vessels in 1993. For Gulf of America Gray Triggerfish discard estimation, complete calendar years 2000-2024 were considered due to management regulations explained below.

Relevant Management History of Gulf of America Gray Triggerfish

There are several management changes relevant to discard estimation: (1) The establishment of a minimum size in late 1999 (12” total length) which increased to a 14” fork length minimum size limit in 2008; and (2) the implementation of seasonal closures starting in 2013 from June through July of each year and various one-time closures from 2012 through 2019 due to quota monitoring.

Gear

In the Gulf of America observer data, Gray Triggerfish were observed on only vertical line trips. Discard estimation was conducted for only this gear.

Spatial Domain

Per recommendation of the stock assessment analysts, discard estimates were conducted in two ways: (1) for the Gulf of America region by zone using area fished information where the eastern zone is fishing areas 1-12 and the western zone represents fishing areas 13-21 (Figure 1); and (2) for the entire Gulf of America region combined. In order to calculate weighted discard length compositions by zone and combined, these analyses were conducted separately. Therefore, discard estimates by zone (east + west) may not equal the discard estimates from the Gulf of America combined analysis.

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). All length data was converted to fork length using the morphometric equations presented in the SEDAR 43 report (SEDAR, 2015). Additionally, when weight information was missing, the length-weight equation from the SEDAR 43 report was used to impute weight (in kilograms). Lastly, total catch was converted from gutted to whole weight (in pounds) using a 1.04 conversion factor.

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).

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):

$$\hat{C} = CPUE * \hat{X},$$

where $CPUE$ 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

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

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 observer 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

$$var[\hat{C}] = var[CPUE] * \widehat{X}^2$$

where the variance of mean CPUE is

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

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

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

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.

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 Gray Triggerfish. 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. 2019), 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, the hindcast discard estimation procedures described in Smith et al. (2019) were applied to Gray Triggerfish. 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 \hat{Y}_h .

$$\hat{Y}_h = CPUE_h * \hat{X}_h$$

and multiplied by stratum proportion of length L to obtain the stratum total discards \hat{Y}_h at length L ,

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

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

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

and then converted to relative proportion of length L ,

$$p(L)_{st} = \frac{\hat{Y}(L)_{st}}{\sum_h \hat{Y}_h}$$

Annual discards-at-length were computed by multiplying the relative proportion at a length bin and annual estimates of total discards.

Results and Discussion

The observer database has a total of 732 vertical line trips with corresponding trip and set information for Gulf of America Gray Triggerfish. Observer sampling effort is summarized in Table 1, distinguishing all trips from the subset of trips that captured Gray Triggerfish by zone. Sample sizes show that observer trips saw Gray Triggerfish more frequently in the East compared to the West region (Table 1).

For the management regimes prior to 2012, the disposition (kept or discarded) of Gulf of America Gray Triggerfish corresponded with the minimum size limit (Fig. 2). Discards were mostly fish near or below the minimum size limit, and kept fish were mostly above the minimum size limit. After closures were implemented starting in 2012, discards included fish below and above the minimum size limit. Discard estimation was conducted separately within these management regimes to account for potential changes in the discard CPUE indicated by differences in the discard length frequencies.

Observer data from the First (2007-2008) management regime were used for hindcasting discards for the pre-observer years 2000-2006, which had the same minimum size limit (12" total length). Following the SEDAR 62 decision, no hindcasted discard estimates were provided pre-2000 because no size limit was in effect and therefore discards were assumed negligible (Smith et al. 2019a).

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting Gray Triggerfish showed general year-to-year fluctuations for the eastern zone and a decreasing trend in the western zone (Fig. 3). Based on the available observer data, the management history of Gray Triggerfish, and trends in annual nominal CPUE, the following management regimes were defined:

- (1) First (2007-2008) associated with a change to including a 12-inch total length minimum size limit
- (2) Second (2009-2011) associated with a 14-inch fork length minimum size limit and before closures were implemented.
- (3) Third (2012) associated with a closure lasting from July 1, 2012 through the end of the year.
- (4) Fourth (2013-2017) associated with two-month seasonal closures and various closures around the end of the year due to quota monitoring.
- (5) Fifth (2018-2024) associated with a more stable nominal CPUE in particularly the eastern Gulf of America zone.

Catch-effort data for observer trips catching Gray Triggerfish were pooled across years for the respective management regimes. Logbook catch-effort data for Gray Triggerfish trips were pooled in the same manner. These observer and logbook datasets were the basis for subsequent analyses and estimation of catch and discards by zone (east and west) and for Gulf of America combined. Limited observer data, particularly from the western zone, prevented fishing season (open and closed) separation of logbook and observer datasets. Instead, shorter management regimes were used to capture variations in discard CPUE by fishing season. For SEDAR 62 (Smith et al. 2019a), discard CPUE was also not calculated by fishing season.

Discard Estimates by Zone (East and West)

Observer and logbook frequency distributions of trip-level catch, effort, and CPUE for First (2007-2008) and Fifth (2018-2024) management regimes in the eastern zone and Third (2012) and Fourth (2013-2017) management regimes in the western zone showed no major divergence, suggesting that observer sampling of Gray Triggerfish trips was representative of the commercial fleet. This was not the case for the other strata (Table 2). For example, in the Third (2012) management regime in the eastern zone, further analysis showed that observers sampled a higher proportion of low catch (<21 lbs.) Gray Triggerfish trips and a lower proportion of moderate (21-50 lbs.) and high catch (>50 lbs.) trips relative to the commercial fleet. 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 Gray Triggerfish that had kept fish are given in Table 3 by management regime and catch or effort level strata. These proportions were used to adjust annual logbook total Gray Triggerfish 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 or effort level strata are given in Table 5. These CPUEs were the basis for expansion estimates of Gray Triggerfish catch and discards. Observer discard CPUEs for the First (2007-2008) were the basis for hindcasting discards during 2000-2006.

CPUE expansion estimates of annual total landed catch of Gulf of America Gray Triggerfish compared favorably with reported logbook landings for 2000-2024 (Fig. 4). CPUE expansion estimates for annual discards in numbers and weight of Gulf of America Gray Triggerfish for 2000-2024 by zone are provided in Table 6. Estimated discards in number ranged from 500 fish in the eastern zone prior to closures to 21,500 fish in the eastern zone in 2012 when the fishery was closed for half of the year. In the western zone, Gray Triggerfish discards averaged about 1,000 fish with the highest number of discards being in 2012 with about 5,000 fish (Fig. 5A). In both the eastern and western zones, discards in weight accounted for about 3% of the total catch (kept + discards) prior to 2008 and up to 50% of the total catch as a result of closures (Fig. 5B). Annual weighted discard length frequencies by zone were provided in 2 cm fork length bins using the catch and effort strata by management regime (Fig. 6).

A comparison between SEDAR 62 and SEDAR 100 discard estimates of Gray Triggerfish by zone (east and west) were comparable, with some divergence of trends limited to after 2015 in the east zone (Fig. 7). Differences could be driven by updated discard rates associated with the changes in stratification from SEDAR 62.

Discard Estimates for the Gulf of America combined

For discard analyses for the entire Gulf of America, similar observer and logbook frequency distributions of trip-level catch, effort, and CPUE were compared. For the management regimes, First (2007-2008), Second (2009-2013), and Fifth (2018-2024), observer trips sampling of Gray Triggerfish was representative of the commercial fleet. In the Third (2012) management regime, catch-level stratification was defined to account for differences in observer sampling relative to

the commercial fleet. Similarly, in the Fourth (2013-2017) management regime, effort-level stratification was applied (Table 7).

Tables 8-10 represent similar tables in the analyses by zone to adjust annual logbook total Gray Triggerfish trips and effort to account for logbook trips that only had discarded fish and mean CPUE by strata. Again, catch verification compared favorably for the combined analysis (Fig 8). CPUE expansion estimates for annual discards in numbers and weight of Gulf of America Gray Triggerfish for the entire region combined for 2000-2024 are provided in Table 11. During the 12-inch total length minimum size limit from 2000 to 2008, discards averaged about 2 percent of the total catch (kept + discards) at an average of 1,700 fish each year (Fig 9). Prior to closures during the 14-inch fork length minimum size limit, discards averaged 27 percent of the total catch and 14,000 fish a year. Once closures were implemented starting in 2012, discards are around 13,000 fish and 40 percent of the total catch. The annual weighted discard length frequencies for Gulf of America combined are shown in Figure 10.

Literature Cited

Atkinson, S., J. Gocke, S. Martinez and E. Scott-Denton. 2021a. Reef Fish Observer Program Metadata. SEDAR74-DW-02. SEDAR, North Charleston, SC. 12 pp.

Atkinson, S., M. Judge, and R. Orhun. 2021b. Coastal Fisheries Logbook Program Metadata. SEDAR74-DW-3. SEDAR, North Charleston, SC. 17 pp.

Jones, C.M., D.S. Robson, H.D. Lakkis, H.D., and J. Kressel. 1995. Properties of catch rates used in analysis of angler surveys. *Transactions of the American Fisheries Society* 124:911-928.

Lohr, S.L. 2010. *Sampling: design and analysis*, 2nd ed. Boston: Brooks/Cole.

Scott-Denton, E., Cryer, P.F., Gocke, J.P., Harrelson, M.R., Kinsella, D.L., Pulver, J.R., Smith, R.C., Williams, J. 2011. Descriptions of the U.S. Gulf of Mexico reef fish bottom longline and vertical line fisheries based on observer data. *Marine Fisheries Review* 73(2):1-26.

SEDAR. 2015. SEDAR 43 Stock Assessment Report Gulf of Mexico Gray Triggerfish. SEDAR, North Charleston SC. 193 pp. available online at: <https://sedarweb.org/assessments/sedar-43/>

Smith, S.G., A.C. Shideler, K.J. McCarthy. 2018. Proposed CPUE Expansion Estimation for Total Discards of Gulf of Mexico Red Grouper. SEDAR61-WP-15. SEDAR, North Charleston, SC. 11 pp.

Smith, S.G., A.C. Shideler, K.J. McCarthy. 2019. Proposed CPUE Expansion Estimation for Total Discards of Gulf of Mexico Gray Triggerfish. SEDAR62-WP-07. SEDAR, North Charleston, SC. 21 pp.

Table 1. Number of total and Gray Triggerfish coastal observer vertical line trips by year for the Gulf of America.

Year	Total Observer Trips	Gray Triggerfish Observer Trips in the Eastern Zone	Gray Triggerfish Observer Trips in the Western Zone
2007	97	41	11
2008	53	11	5
2009	46	11	1
2010	56	20	2
2011	105	44	8
2012	254	119	16
2013	125	54	3
2014	109	40	5
2015	201	77	22
2016	142	58	12
2017	67	29	3
2018	39	14	5
2019	30	11	3
2020	20	11	0
2021	41	23	1
2022	56	18	5
2023	54	21	1
2024	41	22	5

Table 2. Definition of trip catch/effort level strata for Gulf of America Gray Triggerfish, and corresponding percentages of logbook and observer vertical line trips for each zone and management regime.

Zone	Management Regime	Strata Level	Stratum Code	% Trips	
				Logbook	Observer
East	Second 2009-2011	Low, Catch \leq 10 lbs.	L	30.2	40.0
East	Second 2009-2011	Moderate, $10 < \text{Catch} \leq 27$ lbs.	M	24.6	24.0
East	Second 2009-2011	High, Catch > 27 lbs.	H	45.2	36.0
East	Third 2012	Low, Catch ≤ 21 lbs.	L	36.0	77.3
East	Third 2012	Moderate, $21 < \text{Catch} \leq 50$ lbs.	M	21.0	5.9
East	Third 2012	High, Catch > 50 lbs.	H	43.0	16.8
East	Fourth 2013-2017	Low, Catch ≤ 15 lbs.	L	30.9	60.9
East	Fourth 2013-2017	Moderate, $15 < \text{Catch} \leq 36$ lbs.	M	25.6	15.1
East	Fourth 2013-2017	High, Catch > 36 lbs.	H	43.5	24.0
West	First 2007-2008	Low, Effort ≤ 25 hours	L	23.7	46.7
West	First 2007-2008	High, Effort > 25 hours	H	76.3	53.3
West	Second 2009-2011	Low, Catch ≤ 25 lbs.	L	49.8	45.5
West	Second 2009-2011	High, Catch > 25 lbs.	H	50.2	54.5
West	Fifth 2018-2024	Low, Catch ≤ 10 lbs.	L	48.0	75.0
West	Fifth 2018-2024	High, Catch > 10 lbs.	H	52.0	25.0

Table 3. Gulf of America Gray Triggerfish vertical line trip and effort adjustment factors by zone, management regime, and catch/effort level strata. Catch/effort level strata are defined in Table 2; stratum level ‘All’ is all levels (i.e., no stratification) for the management regime. The proportions of Gray Triggerfish observer trips and effort with kept Gray Triggerfish were used to respectively adjust annual logbook total trips and effort (Table 4) to account for logbook trips that only had discarded fish.

Zone	Management Regime	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Gray Triggerfish	
					Trips	Effort
East	First 2007-2008	All	A	52	0.885	0.906
East	Second 2009-2011	Catch	L	30	0.733	0.657
East	Second 2009-2011	Catch	M	18	1	1
East	Second 2009-2011	Catch	H	27	1	1
East	Third 2012	Catch	L	92	0.424	0.446
East	Third 2012	Catch	M	7	1	1
East	Third 2012	Catch	H	20	1	1
East	Fourth 2013-2017	Catch	L	157	0.459	0.501
East	Fourth 2013-2017	Catch	M	39	1	1
East	Fourth 2013-2017	Catch	H	62	1	1
East	Fifth 2018-2024	All	A	120	0.733	0.725
West	First 2007-2008	Effort	L	7	1	1
West	First 2007-2008	Effort	H	8	1	1
West	Second 2009-2011	Catch	L	5	0.8	0.864
West	Second 2009-2011	Catch	H	6	1	1
West	Third 2012	All	A	16	0.625	0.421
West	Fourth 2013-2017	All	A	45	0.511	0.668
West	Fifth 2018-2024	Catch	L	15	0.4	0.588
West	Fifth 2018-2024	Catch	H	5	1	1

Table 4. Annual time-series of vertical line logbook trips (number) and effort (hours) by catch/effort level strata for Gulf of America Gray Triggerfish for each zone (east and west).

Zone (East)

Year	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
			Reported	Adjusted (N)	Reported	Adjusted (\hat{X})
2000	All	A	1,440	1,628	48,288	53,293
2001	All	A	1,505	1,701	47,016	51,889
2002	All	A	1,898	2,146	54,309	59,938
2003	All	A	1,911	2,160	57,707	63,688
2004	All	A	1,751	1,979	52,420	57,853
2005	All	A	1,483	1,676	47,471	52,391
2006	All	A	1,344	1,519	51,685	57,042
2007	All	A	1,088	1,230	45,537	50,256
2008	All	A	1,128	1,275	46,016	50,786
2009	Catch	L	485	661	21,725	33,050
2009	Catch	M	323	323	14,556	14,556
2009	Catch	H	578	578	28,776	28,776
2010	Catch	L	362	494	14,208	21,615
2010	Catch	M	337	337	13,935	13,935
2010	Catch	H	434	434	19,886	19,886
2011	Catch	L	339	462	13,079	19,897
2011	Catch	M	307	307	12,638	12,638
2011	Catch	H	765	765	37,740	37,740
2012	Catch	L	301	710	12,623	28,318
2012	Catch	M	176	176	7,772	7,772
2012	Catch	H	360	360	19,062	19,062
2013	Catch	L	307	669	11,646	23,243
2013	Catch	M	272	272	12,133	12,133
2013	Catch	H	453	453	22,274	22,274
2014	Catch	L	357	778	13,594	27,130
2014	Catch	M	273	273	12,244	12,244
2014	Catch	H	347	347	18,233	18,233
2015	Catch	L	382	833	11,764	23,478
2015	Catch	M	276	276	10,092	10,092
2015	Catch	H	405	405	17,819	17,819
2016	Catch	L	329	717	11,810	23,570
2016	Catch	M	330	330	13,812	13,812

Year	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
			Reported	Adjusted (N)	Reported	Adjusted (\hat{X})
2016	Catch	H	509	509	23,791	23,791
2017	Catch	L	287	626	9,629	19,217
2017	Catch	M	222	222	8,541	8,541
2017	Catch	H	622	622	25,787	25,787
2018	All	A	994	1,355	37,018	51,036
2019	All	A	1,132	1,544	42,674	58,834
2020	All	A	1,017	1,387	36,133	49,816
2021	All	A	933	1,272	35,804	49,362
2022	All	A	955	1,302	37,100	51,149
2023	All	A	1,050	1,432	41,837	57,680
2024	All	A	939	1,280	37,007	51,021

Zone (West)

Year	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
			Reported	Adjusted (N)	Reported	Adjusted (\hat{X})
2000	Effort	L	902	902	11,087	11,087
2000	Effort	H	338	338	20,224	20,224
2001	Effort	L	785	785	9,990	9,990
2001	Effort	H	423	423	23,305	23,305
2002	Effort	L	769	769	9,638	9,638
2002	Effort	H	473	473	26,374	26,374
2003	Effort	L	861	861	11,344	11,344
2003	Effort	H	496	496	26,744	26,744
2004	Effort	L	728	728	9,711	9,711
2004	Effort	H	572	572	28,985	28,985
2005	Effort	L	506	506	7,220	7,220
2005	Effort	H	445	445	24,849	24,849
2006	Effort	L	584	584	8,504	8,504
2006	Effort	H	385	385	19,634	19,634
2007	Effort	L	114	114	1,505	1,505
2007	Effort	H	363	363	25,168	25,168
2008	Effort	L	82	82	949	949
2008	Effort	H	267	267	18,497	18,497
2009	Catch	L	118	148	7,192	8,327
2009	Catch	H	135	135	8,011	8,011

Year	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
			Reported	Adjusted (N)	Reported	Adjusted (\bar{X})
2010	Catch	L	107	134	4,314	4,995
2010	Catch	H	92	92	6,142	6,142
2011	Catch	L	109	136	4,694	5,435
2011	Catch	H	110	110	6,918	6,918
2012	All	A	145	232	8,005	19,020
2013	All	A	134	262	7,144	10,697
2014	All	A	105	205	5,437	8,141
2015	All	A	118	231	6,104	9,139
2016	All	A	152	297	7,315	10,953
2017	All	A	101	198	5,011	7,503
2018	Catch	L	37	92	1,659	2,824
2018	Catch	H	51	51	2,830	2,830
2019	Catch	L	28	70	1,184	2,015
2019	Catch	H	45	45	3,068	3,068
2020	Catch	L	31	78	1,482	2,522
2020	Catch	H	42	42	1,835	1,835
2021	Catch	L	36	90	1,461	2,487
2021	Catch	H	30	30	1,637	1,637
2022	Catch	L	40	100	1,555	2,647
2022	Catch	H	30	30	1,569	1,569
2023	Catch	L	46	115	2,042	3,475
2023	Catch	H	47	47	2,626	2,626
2024	Catch	L	48	120	2,221	3,780
2024	Catch	H	43	43	2,406	2,406

Table 5. Estimated observer mean CPUE in weight by zone (east and west), management regime, and catch/effort level strata for expansion estimates of vertical line Gulf of America Gray Triggerfish catch and discards.

Zone	Management Regime	Strata Type	Strata Level	Logbook CPUE	Observer CPUE		
					Kept	Discard (Weight)	Discard (Number)
East	First 2007-2008	All	A	0.837	0.720	0.012	0.010
East	Second 2009-2011	Catch	L	0.080	0.088	0.056	0.041
East	Second 2009-2011	Catch	M	0.407	0.364	0.084	0.050
East	Second 2009-2011	Catch	H	1.676	1.333	0.620	0.374
East	Third 2012	Catch	L	0.100	0.074	0.522	0.172
East	Third 2012	Catch	M	0.768	0.963	0.422	0.233
East	Third 2012	Catch	H	2.322	2.452	1.309	0.778
East	Fourth 2013-2017	Catch	L	0.101	0.075	0.375	0.140
East	Fourth 2013-2017	Catch	M	0.619	0.467	0.475	0.208
East	Fourth 2013-2017	Catch	H	1.297	1.140	0.462	0.218
East	Fifth 2018-2024	All	A	0.775	0.711	0.564	0.196
West	First 2007-2008	Effort	L	2.733	0.930	0.000	0.000
West	First 2007-2008	Effort	H	1.186	1.916	0.062	0.040
West	Second 2009-2011	Catch	L	0.183	0.198	0.370	0.200
West	Second 2009-2011	Catch	H	1.441	2.921	0.103	0.044
West	Third 2012	All	A	0.358	0.271	0.684	0.262
West	Fourth 2013-2017	All	A	0.301	0.356	0.306	0.115
West	Fifth 2018-2024	Catch	L	0.068	0.050	0.219	0.103
West	Fifth 2018-2024	Catch	H	0.489	1.499	0.175	0.057

Table 6. Time-series of CPUE expansion estimates for Gulf of America Gray Triggerfish vertical line discards by east and west zone in weight (lbs.) and number (with associated standard errors).

Zone (East)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2000	646	187	535	150
2001	875	253	725	204
2002	1,244	359	1,031	290
2003	1,374	397	1,138	320
2004	1,150	332	953	268
2005	1,010	292	837	235
2006	662	191	548	154
2007	590	170	489	137
2008	596	172	494	139
2009	20,896	6,213	12,838	3,888
2010	14,697	4,369	9,015	2,730
2011	25,555	7,598	15,566	4,714
2012	43,011	7,290	21,516	4,019
2013	24,778	3,803	10,641	1,490
2014	24,421	3,748	10,329	1,446
2015	21,837	3,352	9,279	1,299
2016	26,399	4,052	11,366	1,591
2017	23,185	3,559	10,095	1,413
2018	28,778	5,383	10,012	1,784
2019	33,175	6,205	11,542	2,056
2020	28,090	5,254	9,773	1,741
2021	27,834	5,206	9,684	1,725
2022	28,842	5,395	10,034	1,788
2023	32,524	6,084	11,316	2,016
2024	28,769	5,381	10,009	1,783

Zone (West)

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2000	1,623	1,412	1,034	819

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2001	1,491	1,298	950	752
2002	1,606	1,398	1,024	810
2003	1,830	1,592	1,166	923
2004	1,761	1,533	1,122	888
2005	1,268	1,103	808	639
2006	795	692	507	401
2007	1,572	1,368	1,002	793
2008	1,156	1,006	736	583
2009	3,904	2,892	2,015	1,498
2010	2,479	1,837	1,268	943
2011	2,721	2,016	1,390	1,034
2012	13,018	4,829	4,990	1,691
2013	3,272	863	1,228	311
2014	2,490	657	934	236
2015	2,795	737	1,049	265
2016	3,350	883	1,257	318
2017	2,295	605	861	218
2018	1,112	437	451	185
2019	977	384	381	156
2020	872	343	364	149
2021	830	326	349	143
2022	853	335	361	148
2023	1,219	479	507	208
2024	1,247	490	526	215

Table 7. Definition of trip catch/effort level strata for Gulf of America Gray Triggerfish, and corresponding percentages of logbook and observer vertical line trips for each management regime.

Management Regime	Strata Level	Stratum Code	% Trips	
			Logbook	Observer
Third 2012	Low, Catch \leq 17 lbs	L	32.3	74.1
Third 2012	Moderate, $17 <$ Catch \leq 33 lbs	M	16.1	3.7
Third 2012	High, Catch $>$ 33 lbs	H	51.6	22.2
Fourth 2013-2017	Low, Effort \leq 25 hours	L	34.7	33.7
Fourth 2013-2017	Moderate, $25 <$ Effort \leq 40 hours	M	21.7	18.2
Fourth 2013-2017	High, Effort $>$ 40 hours	H	43.6	48.2

Table 8. Gulf of America Gray Triggerfish vertical line trip and effort adjustment factors by management regime and catch/effort level strata. Catch/effort level strata are defined in Table 7; catch level stratum ‘All’ is all levels (i.e., no stratification) for the management regime. The proportions of Gray Triggerfish observer trips and effort with kept Gray Triggerfish were used to respectively adjust annual logbook total trips and effort (Table 9) to account for logbook trips that only had discarded fish.

Management Regime	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Gray Triggerfish	
				Trips	Effort
First 2007-2008	All	A	67	0.91	0.921
Second 2009-2011	All	A	86	0.895	0.911
Third 2012	Catch	L	100	0.41	0.39
Third 2012	Catch	M	5	1	1
Third 2012	Catch	H	30	1	1
Fourth 2013-2017	Effort	L	102	0.471	0.48
Fourth 2013-2017	Effort	M	55	0.673	0.67
Fourth 2013-2017	Effort	H	146	0.76	0.757
Fifth 2018-2024	All	A	140	0.707	0.726

Table 9. Annual time-series of vertical line logbook trips (number) and effort (hours) by catch level strata for Gulf of America Gray Triggerfish.

Year	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
			Reported	Adjusted (N)	Reported	Adjusted (\bar{X})
2000	All	A	2,680	2,944	79,600	86,423
2001	All	A	2,713	2,980	80,312	87,196
2002	All	A	3,140	3,449	90,322	98,064
2003	All	A	3,268	3,589	95,794	104,006
2004	All	A	3,051	3,351	91,116	98,927
2005	All	A	2,434	2,673	79,540	86,359
2006	All	A	2,313	2,541	79,824	86,666
2007	All	A	1,565	1,719	72,210	78,400
2008	All	A	1,477	1,622	65,462	71,074
2009	All	A	1,639	1,831	80,260	88,093
2010	All	A	1,332	1,488	58,486	64,193
2011	All	A	1,630	1,821	75,069	82,395
2012	Catch	L	317	773	13,409	34,388
2012	Catch	M	158	158	7,654	7,654
2012	Catch	H	507	507	26,399	26,399
2013	Effort	L	354	752	5,016	10,455
2013	Effort	M	262	389	9,167	13,683
2013	Effort	H	550	723	39,014	51,539
2014	Effort	L	338	718	4,326	9,016
2014	Effort	M	205	305	7,020	10,479
2014	Effort	H	539	709	38,163	50,415
2015	Effort	L	450	956	5,832	12,156
2015	Effort	M	252	375	8,759	13,074
2015	Effort	H	479	630	31,188	41,201
2016	Effort	L	487	1,035	6,686	13,936
2016	Effort	M	275	409	9,407	14,042
2016	Effort	H	558	734	40,635	53,681
2017	Effort	L	447	950	5,870	12,235
2017	Effort	M	304	452	10,603	15,827
2017	Effort	H	481	633	32,495	42,928
2018	All	A	1,082	1,530	41,506	57,208
2019	All	A	1,205	1,704	46,926	64,678
2020	All	A	1,090	1,541	39,450	54,374

Year	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
			Reported	Adjusted (N)	Reported	Adjusted (\bar{X})
2021	All	A	999	1,413	38,902	53,618
2022	All	A	1,025	1,449	40,225	55,441
2023	All	A	1,143	1,616	46,505	64,097
2024	All	A	1,030	1,457	41,634	57,384

Table 10. Estimated observer mean CPUE in weight by management regime and catch/effort level strata for expansion estimates of vertical line Gulf of America Gray Triggerfish catch and discards.

Management Regime	Strata Type	Strata Level	Logbook CPUE	Observer CPUE		
				Kept	Discard (Weight)	Discard (Number)
First 2007-2008	All	A	0.957	0.891	0.019	0.014
Second 2009-2011	All	A	0.858	0.904	0.303	0.181
Third 2012	Catch	L	0.075	0.059	0.571	0.190
Third 2012	Catch	M	0.500	0.618	0.267	0.142
Third 2012	Catch	H	2.025	2.027	1.075	0.631
Fourth 2013-2017	Effort	L	0.933	0.759	0.745	0.349
Fourth 2013-2017	Effort	M	0.720	0.703	0.647	0.253
Fourth 2013-2017	Effort	H	0.412	0.363	0.321	0.130
Fifth 2018-2024	All	A	0.725	0.688	0.515	0.181

Table 11. Time-series of CPUE expansion estimates for Gray Triggerfish vertical line discards for Gulf of America combined 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	2,034	896	1,502	553
2001	2,210	974	1,632	601
2002	2,811	1,238	2,076	764
2003	3,065	1,351	2,264	834
2004	2,761	1,216	2,039	751
2005	2,119	934	1,565	576
2006	1,556	685	1,149	423
2007	1,460	643	1,078	397
2008	1,323	583	977	360
2009	26,692	7,501	15,977	4,619
2010	19,451	5,466	11,642	3,366
2011	24,966	7,016	14,944	4,320
2012	50,042	8,094	24,285	4,377
2013	33,180	3,940	13,827	1,668
2014	29,674	3,524	12,367	1,492
2015	30,735	3,650	12,920	1,558
2016	36,692	4,358	15,411	1,859
2017	33,128	3,934	13,869	1,673
2018	29,470	5,316	10,380	1,768
2019	33,318	6,010	11,735	1,999
2020	28,010	5,053	9,866	1,680
2021	27,621	4,983	9,729	1,657
2022	28,560	5,152	10,059	1,713
2023	33,019	5,956	11,630	1,981
2024	29,560	5,333	10,412	1,773

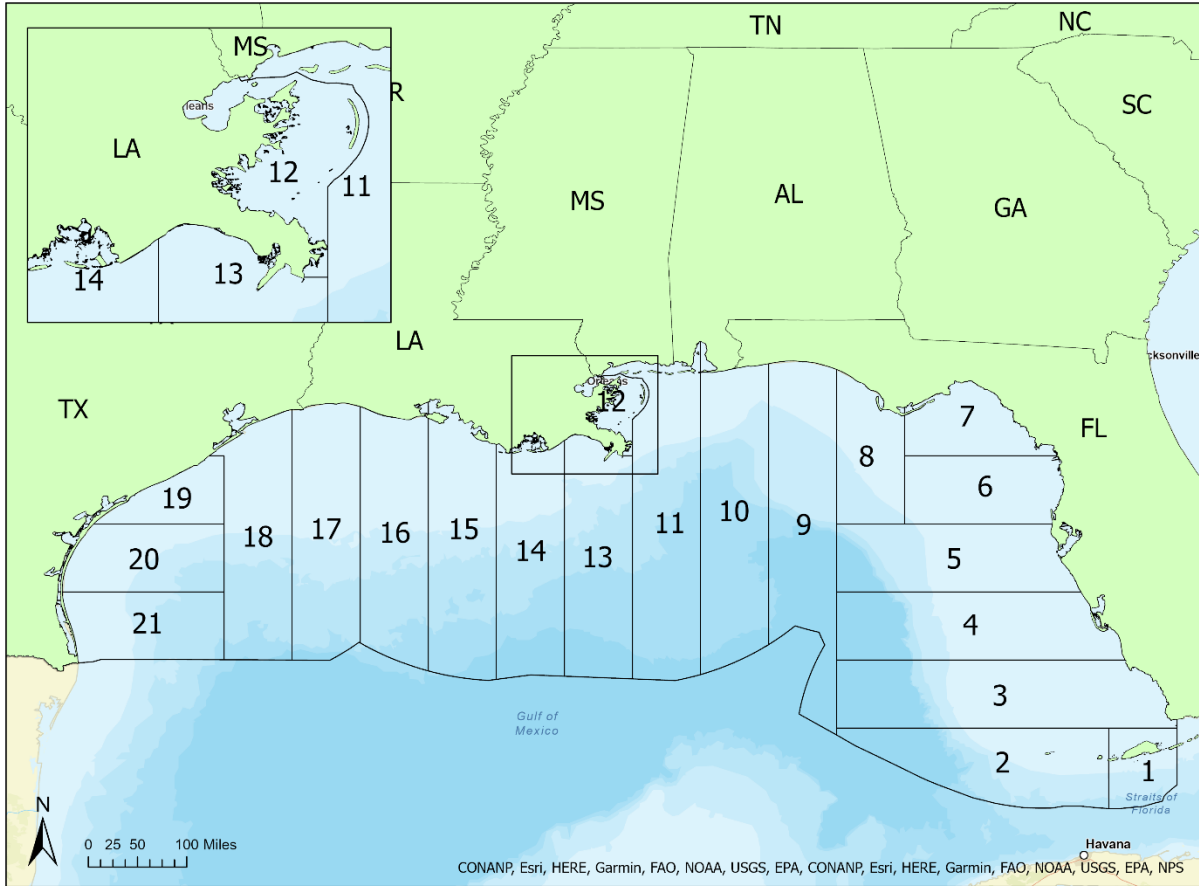


Figure 1. Map of Gulf of America fishing areas.

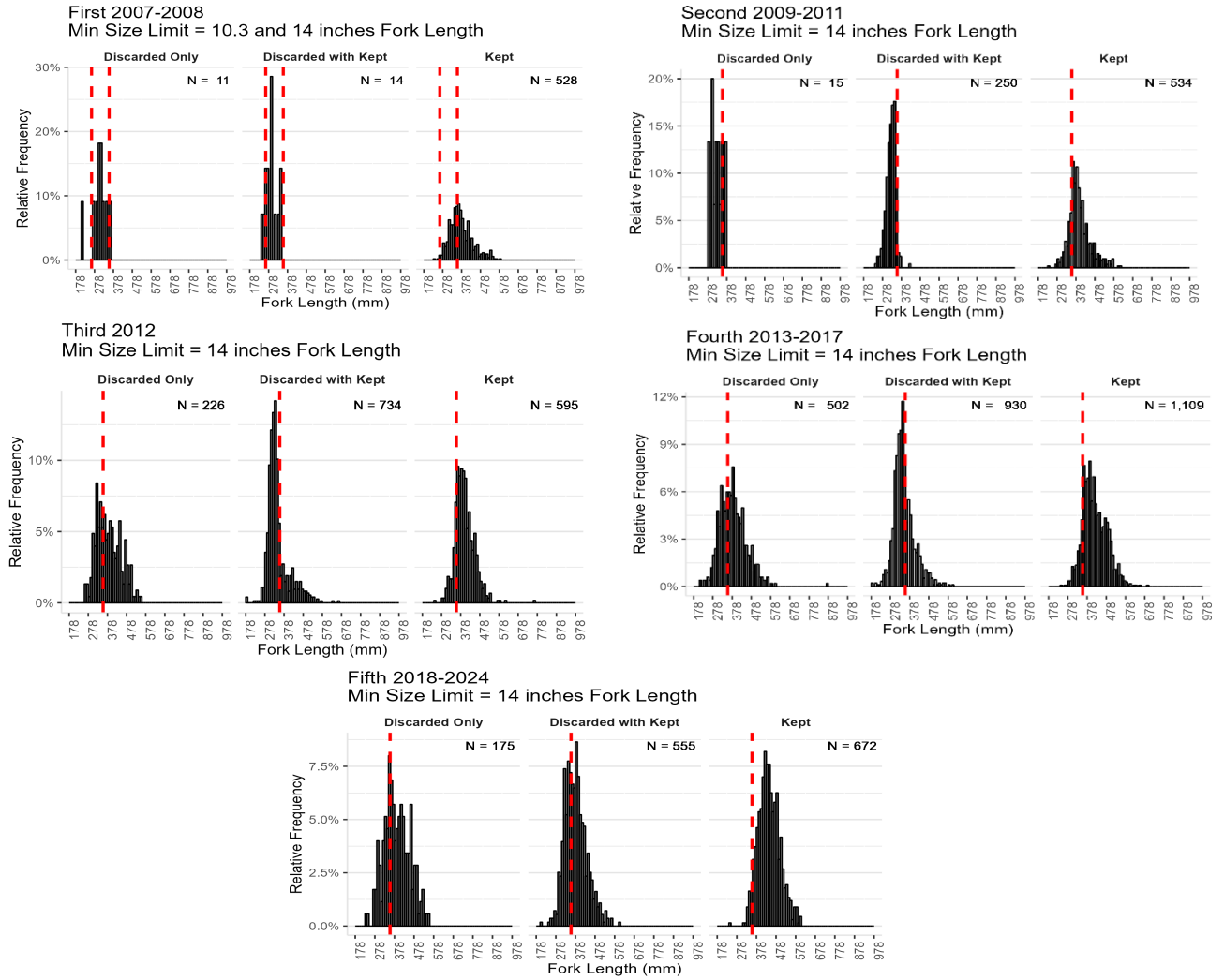


Figure 2. Length-frequency plots of observer vertical line Gulf of America Gray Triggerfish by disposition (Kept or Discard) and management regime. “Discarded Only” were discards from trips with no kept Gray Triggerfish; “Discarded with Kept” were discards from trips with kept Gray Triggerfish. Vertical dashed line denotes the minimum size limit in fork length (FL); N is the number of measured fish.

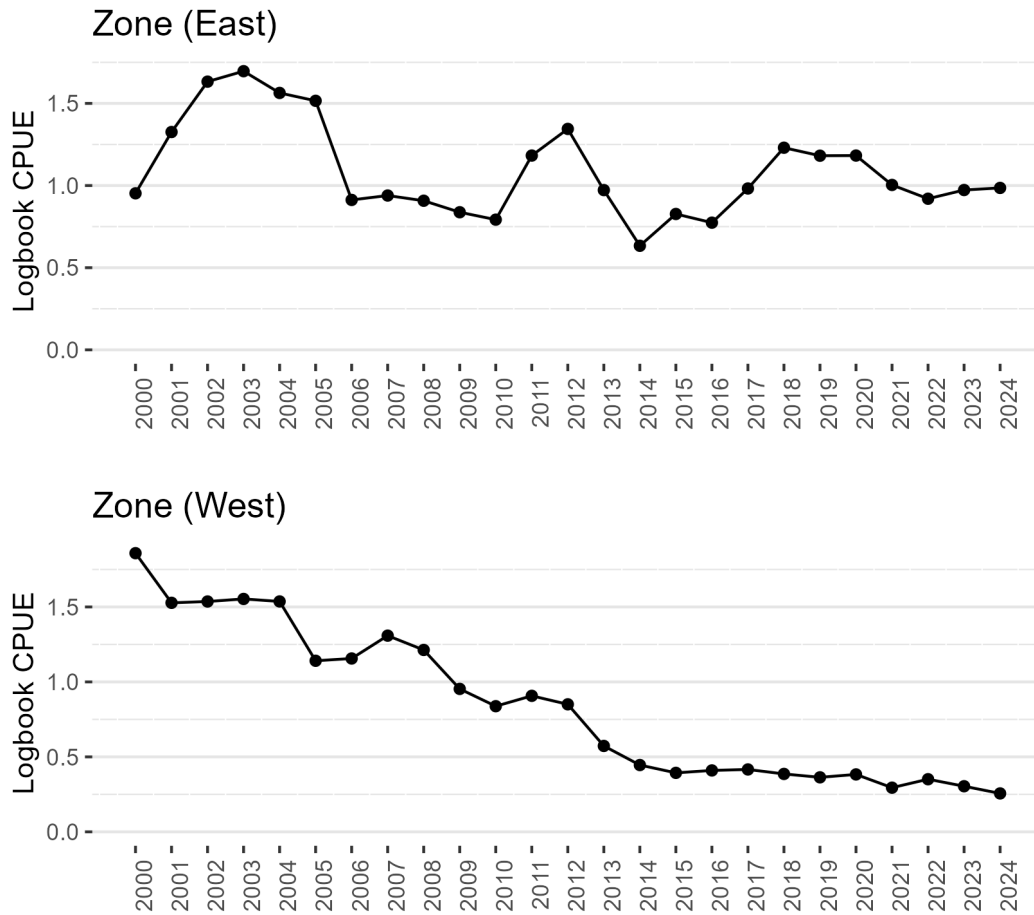


Figure 3. CPUE (catch in whole pounds per hour) time-series for logbook data from 2000 - 2024 for vertical line trips landing Gulf of America Gray Triggerfish.

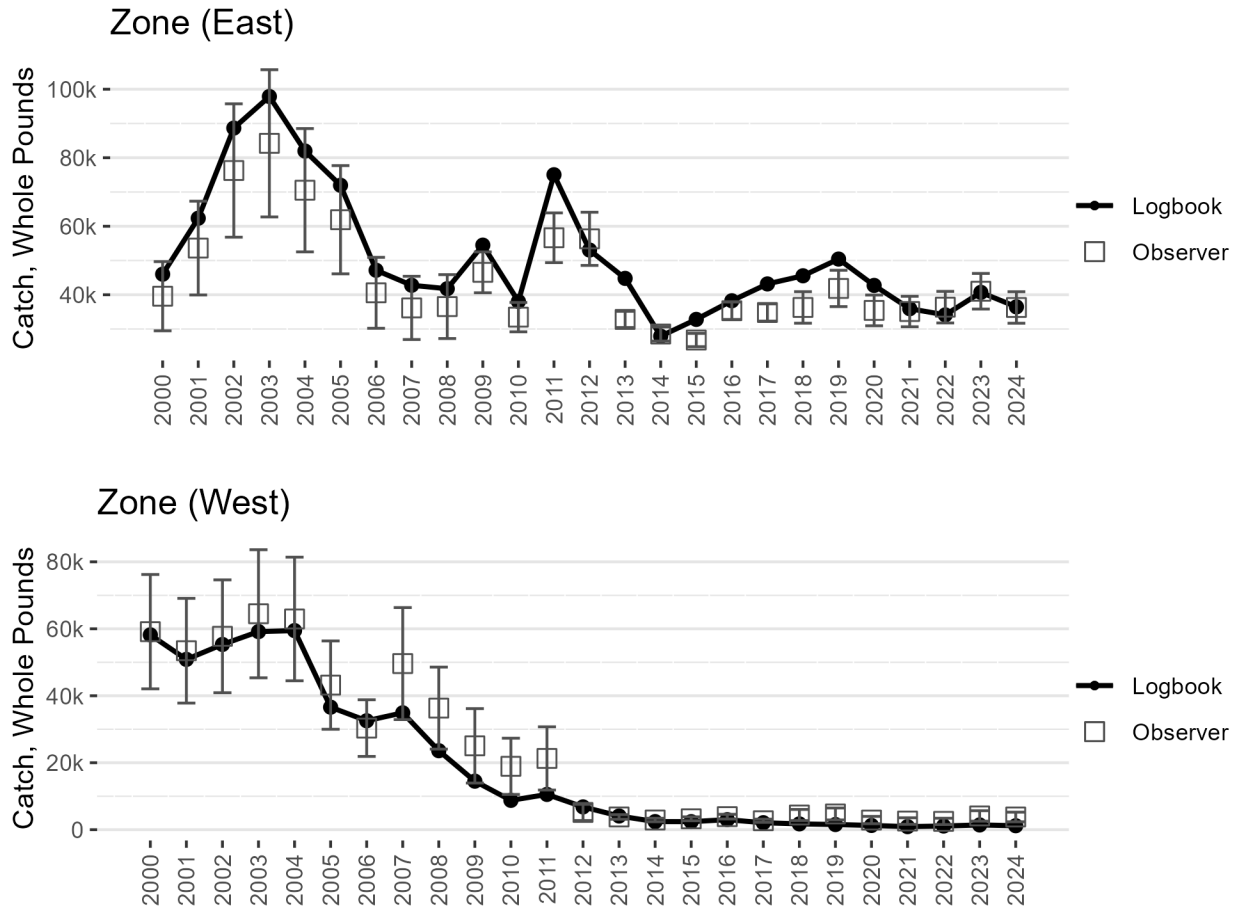
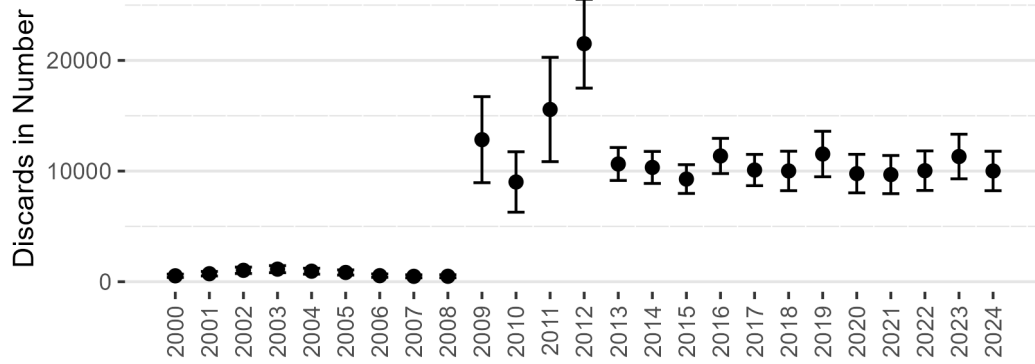
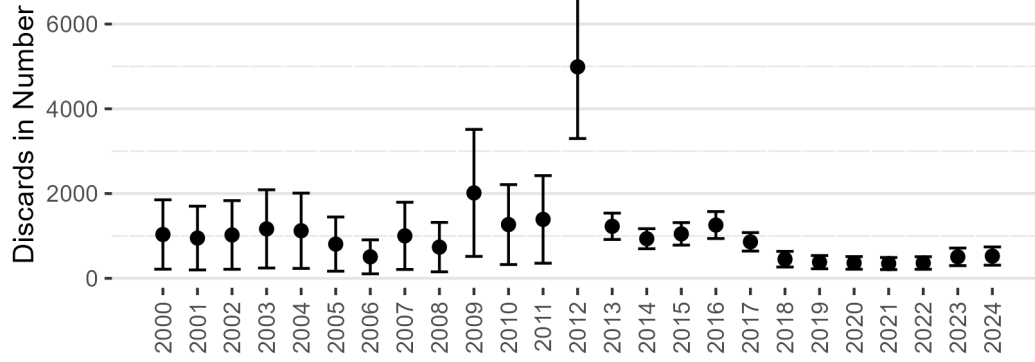


Figure 4. Comparison of vertical line reported annual logbook landings of Gray Triggerfish (solid black line) with CPUE expansion estimates from observer data (open squares) by zone (east and west). Error bars (SE) are shown for observer estimates.

(A) Discards in Number
Zone (East)



Zone (West)



(B) Discards in Weight, Percentage of Total Catch

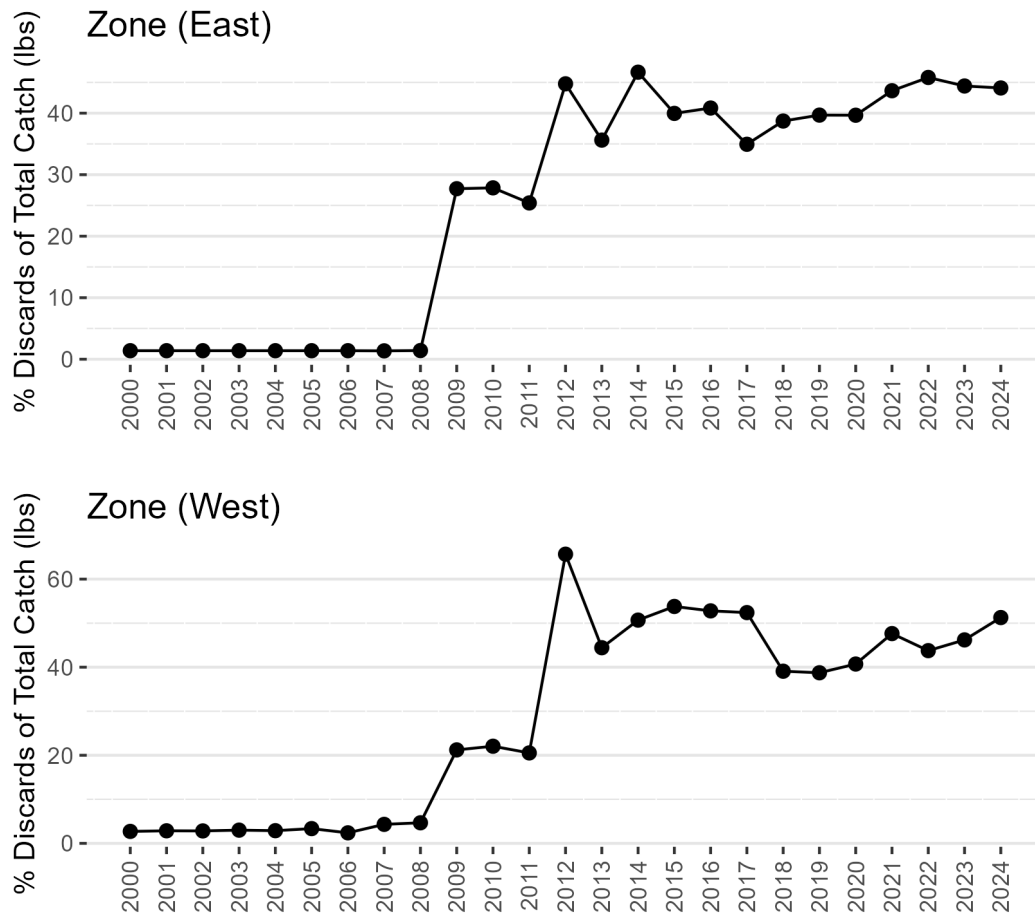


Figure 5. Observer CPUE expansion estimates of Gray Triggerfish commercial vertical line annual discards by zone (east and west) in (A) number (+/-SE) and (B) weight expressed as percentage of total catch (kept + discards) for 2000 - 2024.

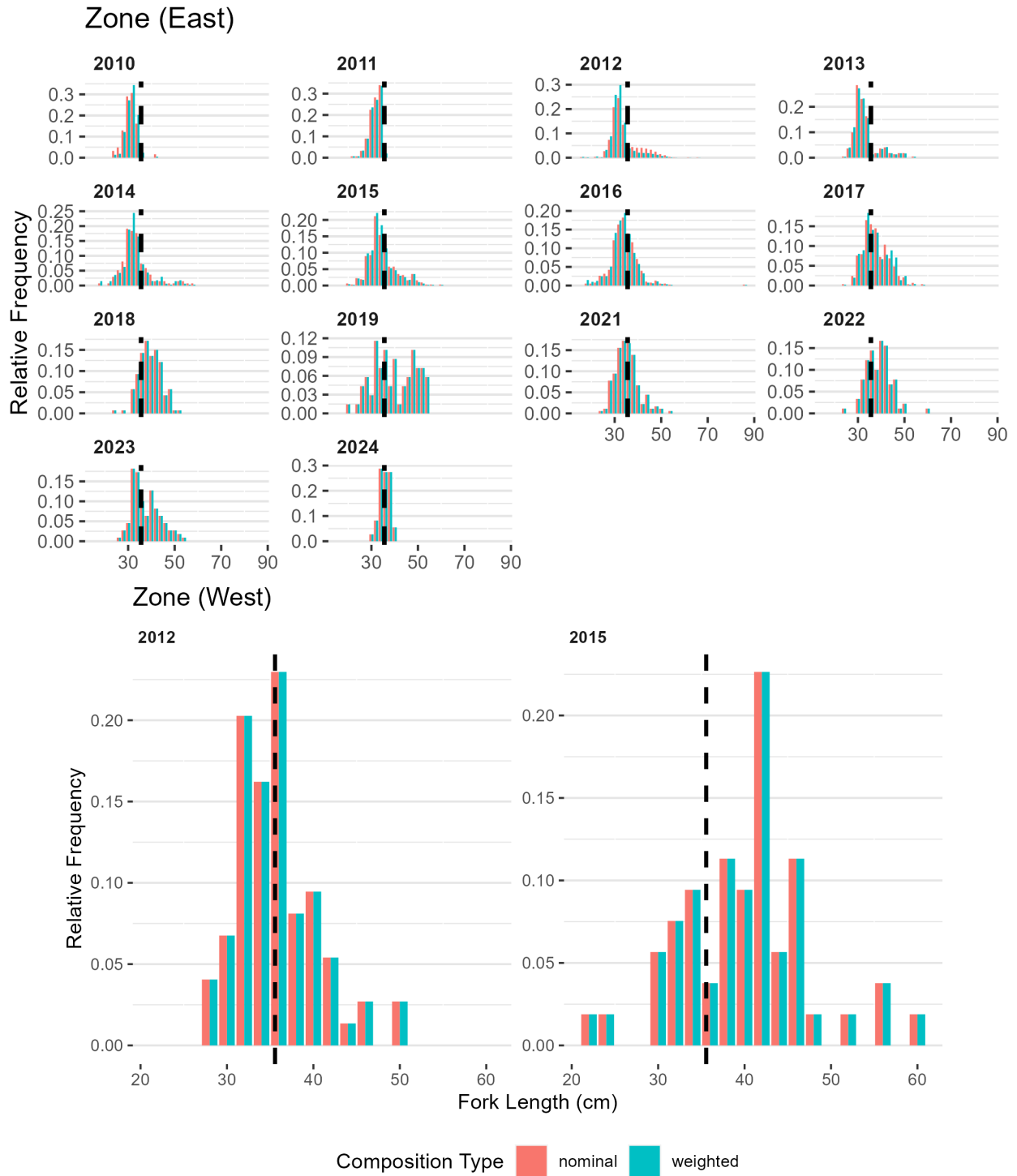


Figure 6. Commercial annual discard length compositions for Gulf of America Gray Triggerfish by zone, where the weighted composition is accounting for catch or effort level stratification by management period. When no catch or effort stratification applied, the nominal and weighted composition will be the same. The vertical line denotes the minimum size limit. Only years meeting the sample size requirements (trips ≥ 3 and fish ≥ 30 in a given year) are shown.

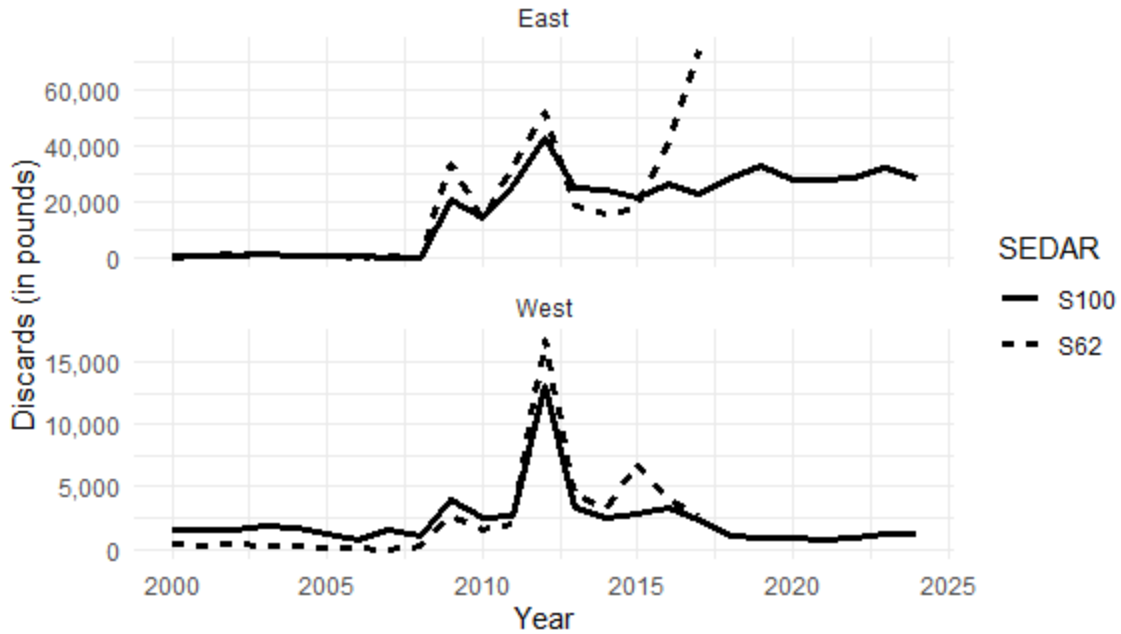


Figure 7. Commercial vertical line discard estimates of Gray Triggerfish for SEDAR 100 compared to SEDAR 62 by Gulf of America zone (east and west).

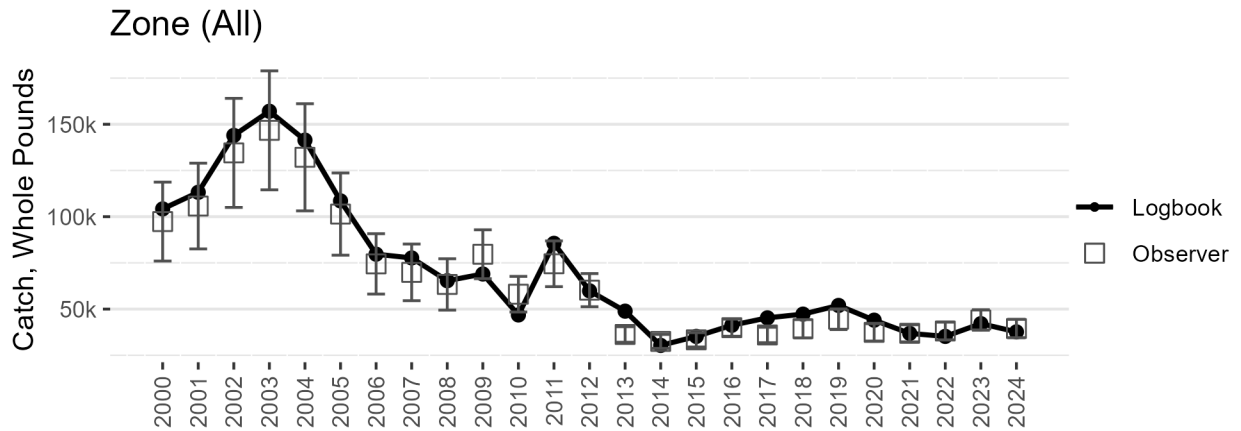
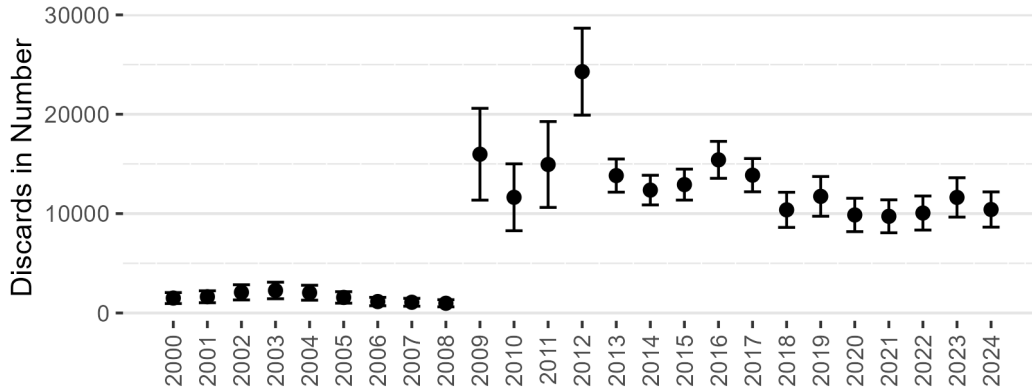


Figure 8. Comparison of vertical line reported annual logbook landings of Gulf of America Gray Triggerfish (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

(A) Discards in Number
Zone (All)



(B) Discards in Weight, Percentage of Total Catch
Zone (All)

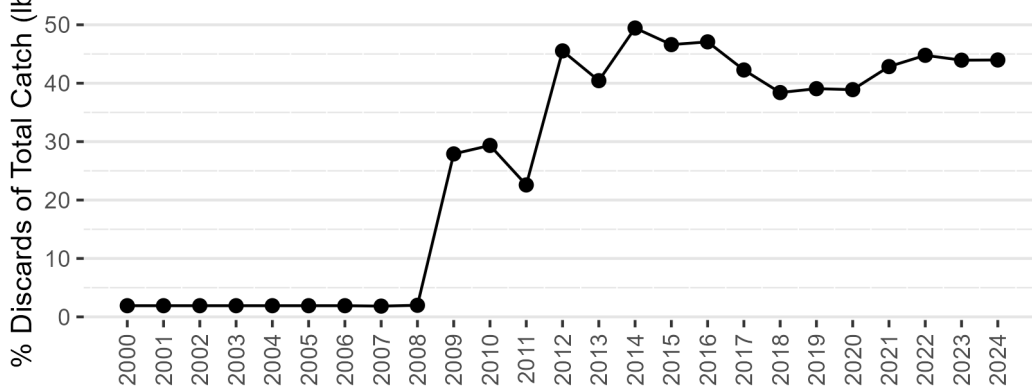


Figure 9. Observer CPUE expansion estimates of Gulf of America Gray Triggerfish commercial vertical line annual discards for the entire region combined in (A) number (+/-SE) and (B) weight expressed as percentage of total catch (kept + discards) for 2000 - 2024.

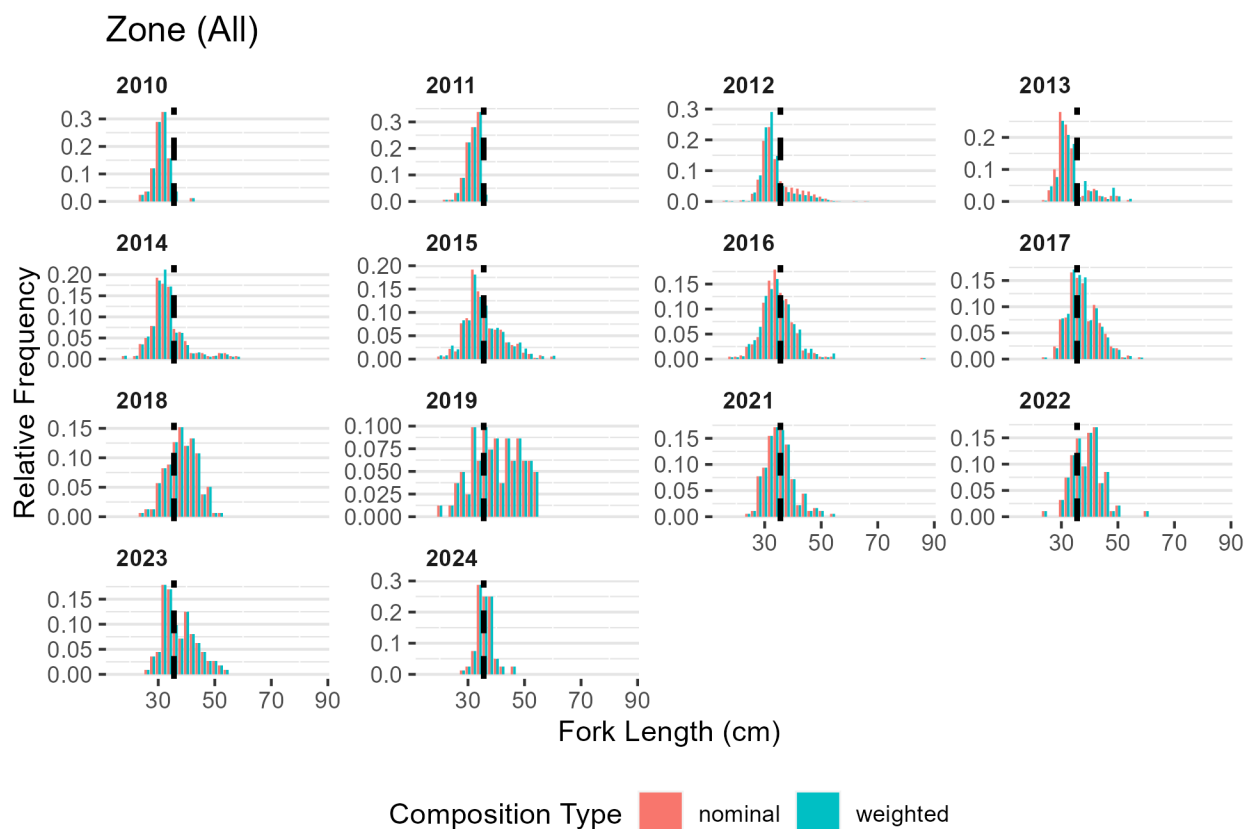


Figure 10. Commercial annual discard length compositions for Gulf of America Gray Triggerfish for the entire region combined, where the weighted composition is accounting for catch or effort level stratification by management period. When no catch or effort stratification applied, the nominal and weighted composition will be the same. The vertical line denotes the minimum size limit. Only years meeting the sample size requirements (trips ≥ 3 and fish ≥ 30 in a given year) are shown.