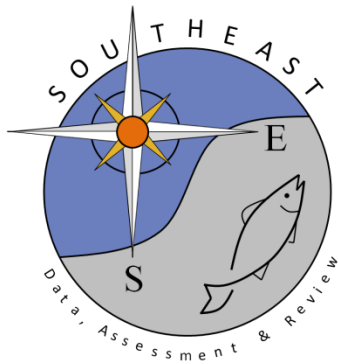


CPUE Expansion Estimation for Commercial Discards of Gulf of America Gag and Associated Weighted Discard Length Composition

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SEDAR105-WP-11

22 May 2026



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Please cite this document as:

Thompson, Kevin, Sarina Atkinson, Gary Decossas. 2026. CPUE Expansion Estimation for Commercial Discards of Gulf of America Gag and Associated Weighted Discard Length Composition. SEDAR105-WP-11. SEDAR, North Charleston, SC. 34 pp.

SEDAR 105 Working Paper

**CPUE Expansion Estimation for Commercial Discards of Gulf of America
Gag and Associated Weighted Discard Length Composition**

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May 2026

SEDAR105-WP-11

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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 methods developed for Gulf of America (formally Gulf of Mexico, hereafter the Gulf) Red Grouper in working paper SEDAR61-WP15 (Smith et al. 2018), Gulf Gray Triggerfish in working paper SEDAR62-WP07 (Smith et al. 2019), and Gulf Vermilion Snapper in working paper SEDAR67-WP12 (Smith et al. 2019) to Gulf of America Gag. Weighted discard length composition methods developed for Gulf Red Snapper (SEDAR 74) were also applied to Gulf Gag, though this method was first documented in working paper SEDAR85-WP06 for Gulf Yellowedge Grouper (Atkinson et al. 2023).

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 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 Reef Fish Observer Program began in July 2006; for Gulf Gag discard estimation, complete calendar years 2007-2024 were used. The methodology is defined by the start year 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 Gag discard estimation, complete calendar years 1993-2024 were considered.

Relevant Management History of Gulf of America Gag

Management changes relevant to discard estimation were: (1) a change in the minimum size limit from 20" TL to 24" TL in 2000; (2) seasonal closures from 2000 to 2009 between February 15 and March 15; (3) the implementation in 2010 of Individual Fishing Quotas (IFQ) for Gulf Gag;

(4) a change in minimum size from 24" TL to 22" TL in 2012; (5) a change in minimum size from 22" TL to 24" TL in 2019, and (6) a significant drop in the commercial quota in 2023.

Gear

In the Gulf observer data Gag were observed on both vertical line and bottom longline trips. Discard estimation was conducted for each gear separately.

Spatial Domain

Per recommendation of the stock assessment analysts, discard estimates were conducted for the Gulf, defined in Figure 1.

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).

Accounting for Gag/Black Grouper Mis-Reporting

Following the discard procedures from Smith et al. (2021a), Gag were misidentified as Black Grouper in the commercial logbook data prior to IFQ. To account for this, discard estimation procedures used logbook effort \hat{X} and logbook total trips N for Gag and Black Grouper combined since it was not possible to distinguish Gag-only trips due to mis-reporting. Logbook annual total catch \hat{C} for Gag was computed by summing the combined total catches of Gag and Black Grouper, and then applying the proportion Gag correction factors described in Smith et al. (2021b). Correspondingly, observer CPUE for the pre-IFQ time period used catch (y) of Gag, but used effort (x) for Gag and Black Grouper combined trips to match with logbook effort for expansion computations.

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):

$$\hat{C} = CP\bar{U}E * \hat{X},$$

where $CP\bar{U}E$ 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

$$CP\bar{U}E = \frac{\bar{y}}{\bar{x}},$$

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

$$var[\hat{C}] = var[CP\bar{U}E] * \hat{X}^2$$

where the variance of mean CPUE is

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

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

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

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 Gag. 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, the hindcast discard estimation procedures described in Smith et al. (2019a) were applied to Gag. 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). Annual length compositions for kept and discarded fish informed the selection of the observer time period used in the hindcasting procedure. 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.

Accounting for Changing Minimum Size Regulations

The standard hindcasting procedure was applied to 2000 where the minimum size limit of Gag was 24" TL. Methods for hindcasting Gag catch and discards to 1993 were modified to approximate the historical 20" TL management regime. Key steps were:

- i. The disposition for individual fish recorded by observers was re-assigned according to the associated minimum legal size, with fish smaller than the minimum size assigned as discards, and fish at or above the minimum size assigned as kept. Fish recorded without lengths were assigned their original disposition. Standard procedures were then carried out to create an observer trip-level catch-effort dataset for the 20" TL management regime.
- ii. Standard computational formulae were used to compute observer mean CPUE and variance, and the proportions of observer trips and effort with kept fish, for each management regime.

- iii. The ratio of observer catch for the historical management regime to the current regime, C_{20}''/C_{24}'' , was used to adjust the annual reported logbook catch during the observer time period for the historical regime.
- iv. Computations of discards for the hindcasting time period were carried out following the procedures for the Trending CPUE method.

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 ,

$$p(L)_{st} = \frac{\hat{Y}(L)_{st}}{\sum_h \hat{Y}_h} (1)$$

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

Results and Discussion

Vertical Line

The observer database included 1,570 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 Gag.

For the pre-IFQ period 2007-2009, the disposition (kept or discarded) of Gulf of America Gag corresponded mostly with the minimum size limit of 24" TL (Fig. 2). Discards were mostly fish near or below the minimum size limit, and kept fish were mostly above the minimum size limit; however, some trips discarded Gag above the minimum size limit because it was during a closed season. For the IFQ period, management regimes were largely determined based on discard length distributions and regulation changes to account for potential changes in the discard CPUE (Fig. 2). The IFQ period was categorized into the following management regimes: IFQ 2010-

2011 24" TL size limit, IFQ 2012-2018 22" TL size limit, IFQ 2019-2022 24" TL size limit, and IFQ 2023-2024 24" TL size limit.

Observer data from the pre-IFQ period (2007-2009) were used for hindcasting discards for the pre-observer years 2000-2006, which had the same minimum size limit (24" TL). Pre-IFQ observer data were also used for hindcasting discards for 1993-1999 with minimum size limit 20" TL after accounting for differences in minimum size (20"TL vs. 24"TL) as described above.

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting Gag remained relatively stable throughout the time series, with slightly higher CPUEs between 1993 and 2005 (Fig. 3). Consequently, nominal CPUE was not used as a criterion for defining management regimes. Catch-effort data for observer trips catching Gag were pooled across years for the respective management regimes. Logbook catch-effort data for Gag and Black 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 by management regime.

Observer and logbook frequency distributions of trip-level catch, effort, and CPUE were similar for pre-IFQ 2007-2009 and IFQ 2010-2011 management regimes, suggesting that observer sampling of Gag trips was representative of the commercial fleet. For years 2012-2018 (IFQ 22" TL), 2019-2022 (IFQ 24" TL), and 2023-2024 (IFQ 24" TL), observer and logbook trips were grouped into strata according to low (L) and high (H) catches or effort to better align the observer data with the commercial fleet (Table 2). For example, observers sampled a slightly higher proportion of low catch (≤ 59 lbs.) Gag trips and a lower proportion of high catch (> 59 lbs.) trips relative to the commercial fleet for the IFQ 2012-2018 management regime.

The proportions of observer trips and effort encountering Gag that had kept fish are given in Table 3A by management regime and catch or effort level strata. These proportions were used to adjust annual logbook total Gag and Black Grouper trips and effort (Table 4) to account for logbook trips that only had discarded fish. Estimates of observer mean CPUE by management regime and catch or effort level strata are given in Table 5. These CPUEs were the basis for expansion estimates of Gag catch and discards. Observer discard CPUEs for the pre-IFQ management regime (2007-2009) were the basis for hindcasting discards during 2000-2006 with the same 24" TL minimum size limit. For the hindcasting period from 1993-1999, the pre-IFQ observer data (2007-2009) was processed so that the disposition of individual fish (kept or discarded) was re-assigned according to the 20" TL size limit. The ratio of observer catches between the historical (20" TL) and current (24" TL) management regimes (Table 3B) was used to adjust logbook catches and CPUE estimates (Table 4). This adjustment accounts for logbook trips that discarded all Gag caught during the 20" minimum size limit period.

CPUE expansion estimates of annual total landed catch of Gulf of America Gag compared favorably with reported logbook landings (Fig. 4). CPUE expansion estimates for annual discards in numbers and weight of Gulf of America Gag for 1993-2024 are provided in Table 6. Estimated discards in number ranged from 17,000 to 102,000 fish during the pre-IFQ management regime 1993-2009 with the peak being in the mid-2000s (Fig. 5A). For the IFQ time period, discards were highest in 2010 and 2011 at the start of the IFQ program and then averaged about 6,500 fish from 2012-2024 (Fig. 5A). Discards in weight accounted for anywhere

between 6 and 40% of the total catch (kept + discards), with 2023 and 2024 being the years with the most discards relative to the total catch (Fig. 5B). This coincides with the significant reduction in Gag quota. Estimated vertical line discards for SEDAR 105 were consistent with SEDAR 72 through 2018 (Fig. 6). The divergence in 2019 stems from differences in data pooling: in SEDAR 72, 2019 was the terminal year and was pooled with 2010–2011 to represent the 24" TL size limit. The current assessment, with a terminal year of 2024, allowed for a more robust pooling, which resulted in the updated estimate for 2019. Annual discard length frequencies were provided in 20 mm fork length bins and weighted using the catch or effort strata by management regime (Fig. 7).

Bottom Longline

The observer database included 708 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 Gag.

For the pre-IFQ period 2007-2009, the disposition (kept or discarded) of Gulf Gag corresponded with the minimum size limit of 24" TL (609 mm FL) (Fig. 8). Discards were mostly fish near or below the minimum size limit, and kept fish were mostly above the minimum size limit. For the initial IFQ period, 2010-2012, discards included fish below and above the minimum size limit. In addition, legal-sized fish were discarded on some of the same trips that kept legal-sized fish. Likely due to the fishery adjusting practices to the IFQ system. Subsequently, discards were primarily undersized fish until the quota change in 2023 where discards included legal-sized fish again (Fig. 8). The IFQ period was categorized into the following management regimes: IFQ 2010-2011 24" TL size limit, IFQ 2012-2018 22" TL size limit, IFQ 2019-2022 24" TL size limit, and IFQ 2023-2024 24" TL size limit to account for potential changes in the discard CPUE indicated by differences in the discard length frequencies.

Observer data from the pre-IFQ period (2007-2009) were used for hindcasting discards for the pre-observer years 2000-2006, which had the same minimum size limit (24" TL). Pre-IFQ observer data were also used for hindcasting discards for 1993-1999 with minimum size limit 20" TL after accounting for differences in minimum size (20"TL vs. 24"TL) as described above.

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting Gag showed a general increase in CPUE until 2005 during the pre-IFQ management regime, followed by a general decrease into the initial IFQ management regime then staying relatively stable with some variation until a drop in the final two years of the time series (Fig. 9) Catch-effort data for observer trips catching Gag were pooled across years for the respective management regimes. Logbook catch-effort data for Gag and Black 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 by management regime.

Observer and logbook frequency distributions of trip-level catch, effort, and CPUE were similar for IFQ 2010-2011 management regimes, suggesting that observer sampling of Gag trips was representative of the commercial fleet. For years Pre-IFQ, 2012-2018 (IFQ 22" TL), 2019-2022 (IFQ 24" TL), and 2023-2024 (IFQ 24" TL), observer and logbook trips were grouped into strata

according to low (L) and high (H) catches to better align the observer data with the commercial fleet (Table 8). For example, observers sampled a higher proportion of low catch (≤ 273 lbs.) Gag trips and a lower proportion of high catch (> 273 lbs.) trips relative to the commercial fleet for the Pre-IFQ management regime.

The proportions of observer trips and effort encountering Gag that had kept fish are given in Table 9A by management regime and catch or effort level strata. These proportions were used to adjust annual logbook total Gag and Black Grouper trips and effort (Table 10) to account for logbook trips that only had discarded fish. Estimates of observer mean CPUE by management regime and catch or effort level strata are given in Table 11. These CPUEs were the basis for expansion estimates of Gag catch and discards. Observer discard CPUEs for the pre-IFQ management regime (2007-2009) were the basis for hindcasting discards during 2000-2006 with the same 24" TL minimum size limit. For the hindcasting period from 1993-1999, the pre-IFQ observer data (2007-2009) was processed so that the disposition of individual fish (kept or discarded) was re-assigned according to the 20" TL size limit. The ratio of observer catches between the historical (20" TL) and current (24" TL) management regimes (Table 9B) was used to adjust logbook catches and CPUE estimates (Table 10). This adjustment accounts for logbook trips that discarded all Gag caught during the 20" minimum size limit period.

CPUE expansion estimates of annual total landed catch of Gulf of America Gag compared favorably with reported logbook landings (Fig. 10). CPUE expansion estimates for annual discards in numbers and weight of Gulf of America Gag for 1993-2024 are provided in Table 12. Estimated discards in number ranged from only 400 to 1,500 fish during the pre-IFQ management regime 1993-2009 with the peak being in the mid-2000s (Fig. 11A). For the IFQ time period, discards increased significantly to over 4,000 fish in some years, with it remaining variable thereafter until 2024 but generally lower in later years (Fig. 11A). Discards in weight as a percent of total catch (kept + discards) was near zero in the Pre-IFQ time period, then quickly increased in 2010 and remained variable with values approaching 50% in the final tow years of the time series (Fig. 11B). This coincides with the significant reduction in Gag quota. Estimated vertical line discards for SEDAR 105 were consistent with SEDAR 72 through 2018 (Fig. 12). The divergence in 2019 stems from differences in data pooling: in SEDAR 72, 2019 was the terminal year and was pooled with 2010–2011 to represent the 24" TL size limit. The current assessment, with a terminal year of 2024, allowed for a more robust pooling, which resulted in the updated estimate for 2019. Annual discard length frequencies were provided in 20 mm fork length bins and weighted using the catch or effort strata by management regime (Fig. 13).

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

Year	Total Trips	Gag Trips
2007	97	58
2008	53	32
2009	46	27
2010	56	30
2011	105	66
2012	254	162
2013	125	63
2014	109	48
2015	201	90
2016	142	69
2017	67	22
2018	39	20
2019	30	10
2020	20	6
2021	41	17
2022	56	26
2023	54	27
2024	75	25

Table 2. Definition of trip strata levels for Gulf of America Gag, and corresponding percentages of logbook and observer vertical line trips for each zone and management regime.

Zone	Management Regime	Season	Strata Level	Stratum Code	% Trips	
					Logbook	Observer
All	IFQ 2012-2018 22inTL	Open	Low, Catch \leq 59 lbs	L	49.5	54.2
All	IFQ 2012-2018 22inTL	Open	High, Catch $>$ 59 lbs	H	50.5	45.8
All	IFQ 2019-2022 24inTL	Open	Low, Catch \leq 73 lbs	L	51.6	49.2
All	IFQ 2019-2022 24inTL	Open	High, Catch $>$ 73 lbs	H	48.4	50.8
All	IFQ 2023-2024 24inTL	Open	Low, Effort \leq 29 hours	L	33.2	29.4
All	IFQ 2023-2024 24inTL	Open	High, Effort $>$ 29 hours	H	66.8	70.6

Table 3. Gulf of America Gag vertical line trip and effort adjustment factors by management regime and catch/effort level strata. Strata levels are defined in Table 2; where stratum ‘All’ is all levels (i.e., no stratification) for the management regime. The proportions of Gag observer trips and effort with kept Gag were used to respectively adjust annual logbook total trips and effort (Table 4) to account for logbook trips that only had discarded fish. (B) Ratios of observer catch for a historical management regime to the current regime were used to adjust logbook catches and CPUE estimates (Table 4) for hindcasting for historical management regimes.

(A)

Zone	Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Gag	
						Trips	Effort
All	Pre-IFQ	Closed	All	A	7	0.571	0.575
All	Pre-IFQ	Open	All	A	110	0.845	0.892
All	IFQ 2010-2011 24inTL	Open	All	A	96	0.812	0.883
All	IFQ 2012-2018 22inTL	Open	Catch	L	257	0.72	0.779
All	IFQ 2012-2018 22inTL	Open	Catch	H	217	1	1
All	IFQ 2019-2022 24inTL	Open	Catch	L	29	0.966	0.993
All	IFQ 2019-2022 24inTL	Open	Catch	H	30	1	1
All	IFQ 2023-2024 24inTL	Open	Effort	L	15	0.667	0.725
All	IFQ 2023-2024 24inTL	Open	Effort	H	36	0.806	0.771

Zone	Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Gag	
						Trips	Effort

(B)

Description	Ratio
C_{20}/C_{24}	1.1544

Table 4. Annual time-series of vertical line logbook trips (number) and effort (hours) by catch/effort level strata for Gulf of America Gag.

Year	Season	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
				Reported	Adjusted (N)	Reported	Adjusted (\hat{X})
1993	Open	All	A	4,196	4,616	143,895	153,791
1994	Open	All	A	4,733	5,206	152,968	163,487
1995	Open	All	A	4,818	5,300	153,127	163,658
1996	Open	All	A	5,242	5,766	168,410	179,992
1997	Open	All	A	5,556	6,112	174,571	186,576
1998	Open	All	A	7,108	7,819	188,896	201,886
1999	Open	All	A	7,215	7,936	201,833	215,713
2000	Open	All	A	6,938	8,206	199,275	223,399
2001	Closed	All	A	55	96	1,184	2,059
2001	Open	All	A	6,214	7,350	188,544	211,369
2002	Closed	All	A	65	114	1,222	2,125
2002	Open	All	A	6,203	7,337	189,466	212,402
2003	Closed	All	A	69	121	1,362	2,369
2003	Open	All	A	6,061	7,169	189,402	212,331
2004	Closed	All	A	94	164	2,630	4,574
2004	Open	All	A	5,601	6,625	168,502	188,901
2005	Closed	All	A	96	168	2,343	4,075
2005	Open	All	A	4,607	5,449	153,649	172,250
2006	Closed	All	A	42	74	973	1,692
2006	Open	All	A	4,466	5,282	164,462	184,373
2007	Closed	All	A	34	60	974	1,694
2007	Open	All	A	3,607	4,266	151,197	169,501
2008	Closed	All	A	18	32	439	763
2008	Open	All	A	3,583	4,238	144,682	162,198
2009	Open	All	A	3,621	4,283	170,104	190,696
2010	Open	All	A	2,395	2,948	111,866	126,745
2011	Open	All	A	1,950	2,400	90,837	102,919
2012	Open	Catch	L	1,083	1,504	38,690	49,675
2012	Open	Catch	H	1,300	1,300	66,351	66,351
2013	Open	Catch	L	1,050	1,459	40,823	52,414
2013	Open	Catch	H	1,194	1,194	65,245	65,245
2014	Open	Catch	L	1,227	1,705	50,018	64,219
2014	Open	Catch	H	1,105	1,105	58,639	58,639

Year	Season	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
				Reported	Adjusted (N)	Reported	Adjusted (\hat{X})
2015	Open	Catch	L	1,156	1,606	46,013	59,077
2015	Open	Catch	H	767	767	39,037	39,037
2016	Open	Catch	L	1,001	1,391	37,261	47,840
2016	Open	Catch	H	1,233	1,233	62,348	62,348
2017	Open	Catch	L	956	1,328	36,407	46,744
2017	Open	Catch	H	997	997	46,725	46,725
2018	Open	Catch	L	879	1,221	30,999	39,800
2018	Open	Catch	H	912	912	40,083	40,083
2019	Open	Catch	L	924	957	30,981	31,214
2019	Open	Catch	H	840	840	36,599	36,599
2020	Open	Catch	L	916	949	31,030	31,264
2020	Open	Catch	H	724	724	30,486	30,486
2021	Open	Catch	L	905	937	31,111	31,345
2021	Open	Catch	H	817	817	34,665	34,665
2022	Open	Catch	L	727	753	23,707	23,886
2022	Open	Catch	H	870	870	37,002	37,002
2023	Open	Effort	L	371	556	5,668	7,821
2023	Open	Effort	H	826	1,025	41,765	54,138
2024	Open	Effort	L	342	513	5,298	7,311
2024	Open	Effort	H	611	758	31,237	40,491

Table 5. Estimated observer mean CPUE in weight (lbs.) and number by management regime and catch/effort level strata for expansion estimates of vertical line Gulf of America Gag catch and discards.

Zone	Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Observer CPUE		
						Kept (Weight)	Discard (Weight)	Discard (Number)
All	Pre-IFQ	Closed	All	A	2.642	1.333	0.510	0.029
All	Pre-IFQ	Open	All	A	3.509	3.542	0.806	0.208
All	IFQ 2010-2011 24inTL	Open	All	A	2.371	2.289	1.087	0.275
All	IFQ 2012-2018 22inTL	Open	Catch	L	0.501	0.424	0.400	0.059
All	IFQ 2012-2018 22inTL	Open	Catch	H	5.088	5.747	0.459	0.109
All	IFQ 2019-2022 24inTL	Open	Catch	L	0.884	0.942	0.127	0.034
All	IFQ 2019-2022 24inTL	Open	Catch	H	7.228	5.375	0.419	0.109
All	IFQ 2023-2024 24inTL	Open	Effort	L	2.895	2.841	3.703	0.389
All	IFQ 2023-2024 24inTL	Open	Effort	H	1.670	1.312	0.775	0.065

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

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
1993	50,725	10,535	17,933	3,896
1994	49,889	10,362	17,638	3,832
1995	56,009	11,633	19,801	4,302
1996	62,109	12,900	21,958	4,770
1997	63,583	13,206	22,479	4,883
1998	101,190	21,017	35,774	7,772
1999	82,290	17,091	29,093	6,320
2000	337,192	112,868	87,228	18,939
2001	399,070	132,347	102,486	22,206
2002	384,177	127,343	98,622	21,366
2003	325,426	107,589	83,369	18,051
2004	352,120	116,170	90,058	19,491
2005	326,417	107,644	83,456	18,060
2006	186,607	62,047	48,021	10,411
2007	137,404	45,993	35,370	7,679
2008	131,046	43,865	33,821	7,343
2009	153,614	51,419	39,738	8,628
2010	137,821	33,068	34,867	9,129
2011	111,913	26,852	28,313	7,413
2012	50,342	7,078	10,149	1,415
2013	50,930	7,161	10,191	1,421
2014	52,622	7,399	10,173	1,419
2015	41,565	5,844	7,739	1,079
2016	47,770	6,716	9,606	1,340
2017	40,159	5,646	7,844	1,094
2018	34,331	4,827	6,711	936
2019	19,303	6,968	5,052	1,738
2020	16,747	6,046	4,388	1,510
2021	18,509	6,682	4,846	1,667
2022	18,541	6,693	4,846	1,667
2023	70,921	18,595	6,537	1,432
2024	58,456	15,327	5,458	1,196

Table 7. Number of total and Gag coastal observer bottom longline trips by year for the Gulf of America.

Year	Total Trips	Gag Trips
2007	29	15
2008	5	1
2009	40	25
2010	79	53
2011	91	79
2012	58	35
2013	82	68
2014	27	22
2015	30	22
2016	71	48
2017	34	16
2018	37	4
2019	20	7
2020	5	0
2021	25	8
2022	33	23
2023	25	17
2024	17	11

Table 8. Definition of trip strata levels for Gulf of America Gag, and corresponding percentages of logbook and observer bottom longline trips for each zone and management regime.

Zone	Management Regime	Season	Strata Level	Stratum Code	% Trips	
					Logbook	Observer
All	Pre-IFQ	Open	Low, Catch <= 273 lbs	L	56.1	73.2
All	Pre-IFQ	Open	High, Catch > 273 lbs	H	43.9	26.8
All	IFQ 2012-2018 22inTL	Open	Low, Catch <= 159 lbs	L	48.5	39.5
All	IFQ 2012-2018 22inTL	Open	High, Catch > 159 lbs	H	51.5	60.5
All	IFQ 2019-2022 24inTL	Open	Low, Catch <= 156 lbs	L	48.3	36.8
All	IFQ 2019-2022 24inTL	Open	High, Catch > 156 lbs	H	51.7	63.2
All	IFQ 2023-2024 24inTL	Open	Low, Catch <= 96 lbs	L	46.4	60.7

Zone	Management Regime	Season	Strata Level	Stratum Code	% Trips	
					Logbook	Observer
All	IFQ 2023-2024 24inTL	Open	High, Catch > 96 lbs	H	53.6	39.3

Table 9. Gulf of America Gag bottom longline trip and effort adjustment factors by management regime and catch/effort level strata. Strata levels are defined in Table 8; where stratum ‘All’ is all levels (i.e., no stratification) for the management regime. The proportions of Gag observer trips and effort with kept Gag were used to respectively adjust annual logbook total trips and effort (Table 10) to account for logbook trips that only had discarded fish. Ratios of observer catch for a historical management regime to the current regime were used to adjust logbook catches and CPUE estimates (Table 10) for hindcasting for historical management regimes.

(A)

Zone	Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Gag	
						Trips	Effort
All	Pre-IFQ	Open	Catch	L	30	0.933	0.922
All	Pre-IFQ	Open	Catch	H	11	1	1
All	IFQ 2010-2011 24inTL	Open	All	A	132	0.826	0.843
All	IFQ 2012-2018 22inTL	Open	Catch	L	85	0.906	0.921
All	IFQ 2012-2018 22inTL	Open	Catch	H	130	1	1
All	IFQ 2019-2022 24inTL	Open	Catch	L	14	0.929	0.888
All	IFQ 2019-2022 24inTL	Open	Catch	H	24	1	1
All	IFQ 2023-2024 24inTL	Open	Catch	L	17	0.706	0.819
All	IFQ 2023-2024 24inTL	Open	Catch	H	11	1	1

(B)

Description	Strata Type	Strata Level	Ratio
C_{20}/C_{24}	Catch	H	1.0041
C_{20}/C_{24}	Catch	L	1.0226

Table 10. Annual time-series of bottom longline logbook trips (number) and effort (hours) by catch/effort level strata for Gulf of America Gag.

Year	Season	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
				Reported	Adjusted (N)	Reported	Adjusted (\hat{X})
1993	Open	Catch	L	587	587	15,756	15,756
1993	Open	Catch	H	362	362	13,363	13,363
1994	Open	Catch	L	806	806	22,047	22,047
1994	Open	Catch	H	281	281	10,058	10,058
1995	Open	Catch	L	739	739	16,158	16,158
1995	Open	Catch	H	313	313	11,145	11,145
1996	Open	Catch	L	839	839	19,264	19,264
1996	Open	Catch	H	383	383	12,558	12,558
1997	Open	Catch	L	790	790	19,828	19,828
1997	Open	Catch	H	438	438	14,652	14,652
1998	Open	Catch	L	627	627	13,790	13,790
1998	Open	Catch	H	579	579	18,495	18,495
1999	Open	Catch	L	685	685	17,778	17,778
1999	Open	Catch	H	488	488	15,060	15,060
2000	Open	Catch	L	587	629	13,598	14,752
2000	Open	Catch	H	538	538	16,377	16,377
2001	Open	Catch	L	499	535	9,953	10,798
2001	Open	Catch	H	691	691	20,882	20,882
2002	Open	Catch	L	511	548	9,936	10,779
2002	Open	Catch	H	626	626	17,691	17,691
2003	Open	Catch	L	546	585	10,219	11,086
2003	Open	Catch	H	724	724	19,056	19,056
2004	Open	Catch	L	533	571	9,925	10,768
2004	Open	Catch	H	694	694	16,853	16,853
2005	Open	Catch	L	439	470	7,089	7,690
2005	Open	Catch	H	696	696	15,009	15,009
2006	Open	Catch	L	637	682	12,125	13,154
2006	Open	Catch	H	613	613	12,754	12,754
2007	Open	Catch	L	461	494	9,449	10,251
2007	Open	Catch	H	413	413	10,344	10,344
2008	Open	Catch	L	535	573	12,175	13,208
2008	Open	Catch	H	376	376	9,094	9,094
2009	Open	Catch	L	243	260	5,948	6,453

Year	Season	Strata Type	Strata Level	Logbook Trips		Logbook Effort	
				Reported	Adjusted (N)	Reported	Adjusted (\hat{X})
2009	Open	Catch	H	179	179	4,863	4,863
2010	Open	All	A	345	418	10,140	12,032
2011	Open	All	A	360	436	10,744	12,749
2012	Open	Catch	L	192	212	5,224	5,673
2012	Open	Catch	H	213	213	6,162	6,162
2013	Open	Catch	L	195	215	5,720	6,211
2013	Open	Catch	H	285	285	8,148	8,148
2014	Open	Catch	L	264	291	8,236	8,944
2014	Open	Catch	H	259	259	8,897	8,897
2015	Open	Catch	L	256	283	8,326	9,041
2015	Open	Catch	H	287	287	10,072	10,072
2016	Open	Catch	L	263	290	8,540	9,274
2016	Open	Catch	H	359	359	12,185	12,185
2017	Open	Catch	L	307	339	10,712	11,632
2017	Open	Catch	H	257	257	9,374	9,374
2018	Open	Catch	L	289	319	9,858	10,705
2018	Open	Catch	H	218	218	7,996	7,996
2019	Open	Catch	L	258	278	8,417	9,483
2019	Open	Catch	H	197	197	6,671	6,671
2020	Open	Catch	L	255	275	7,247	8,165
2020	Open	Catch	H	222	222	6,380	6,380
2021	Open	Catch	L	233	251	6,085	6,856
2021	Open	Catch	H	290	290	7,995	7,995
2022	Open	Catch	L	194	209	4,484	5,052
2022	Open	Catch	H	00299	299	7,587	7,587
2023	Open	Catch	L	159	225	4,520	5,517
2023	Open	Catch	H	221	221	6,494	6,494
2024	Open	Catch	L	146	207	4,148	5,063
2024	Open	Catch	H	131	131	4,174	4,174

Table 11. Estimated observer mean CPUE in weight (lbs.) and number by management regime and catch/effort level strata for expansion estimates of bottom longline Gulf of America Gag catch and discards.

Zone	Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Observer CPUE		
						Kept (Weight)	Discard (Weight)	Discard (Number)
All	Pre-IFQ	Open	Catch	L	4.320	4.274	0.206	0.041
All	Pre-IFQ	Open	Catch	H	32.608	33.070	0.253	0.033
All	IFQ 2010-2011 24inTL	Open	All	A	7.532	7.877	3.665	0.319
All	IFQ 2012-2018 22inTL	Open	Catch	L	1.929	1.942	2.941	0.175
All	IFQ 2012-2018 22inTL	Open	Catch	H	20.621	21.244	2.656	0.201
All	IFQ 2019-2022 24inTL	Open	Catch	L	1.868	1.464	0.029	0.009
All	IFQ 2019-2022 24inTL	Open	Catch	H	24.258	29.965	0.768	0.113
All	IFQ 2023-2024 24inTL	Open	Catch	L	1.290	1.072	2.642	0.177
All	IFQ 2023-2024 24inTL	Open	Catch	H	11.550	10.076	5.099	0.279

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

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
1993	2,270	577	540	135
1994	2,491	634	600	150
1995	2,467	628	590	148
1996	2,975	757	713	178
1997	2,970	755	708	177
1998	3,471	883	814	204
1999	3,324	846	785	196
2000	7,073	1,204	1,141	177
2001	8,978	1,604	1,386	217
2002	9,132	1,644	1,402	220
2003	9,904	1,779	1,523	239
2004	9,179	1,655	1,407	222
2005	8,328	1,500	1,278	201
2006	7,299	1,230	1,201	187

Year	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2007	4,723	1,124	770	168
2008	5,015	1,193	851	186
2009	2,556	608	430	94
2010	44,103	7,634	3,833	586
2011	46,730	8,089	4,061	621
2012	33,050	8,010	2,227	463
2013	39,909	9,673	2,719	566
2014	49,933	12,103	3,347	696
2015	53,342	12,929	3,599	749
2016	59,638	14,455	4,064	845
2017	59,107	14,326	3,912	814
2018	52,719	12,778	3,474	722
2019	5,395	2,415	835	229
2020	5,134	2,298	791	217
2021	6,337	2,837	962	264
2022	5,972	2,674	900	247
2023	47,689	18,664	2,793	972
2024	34,660	13,565	2,064	718

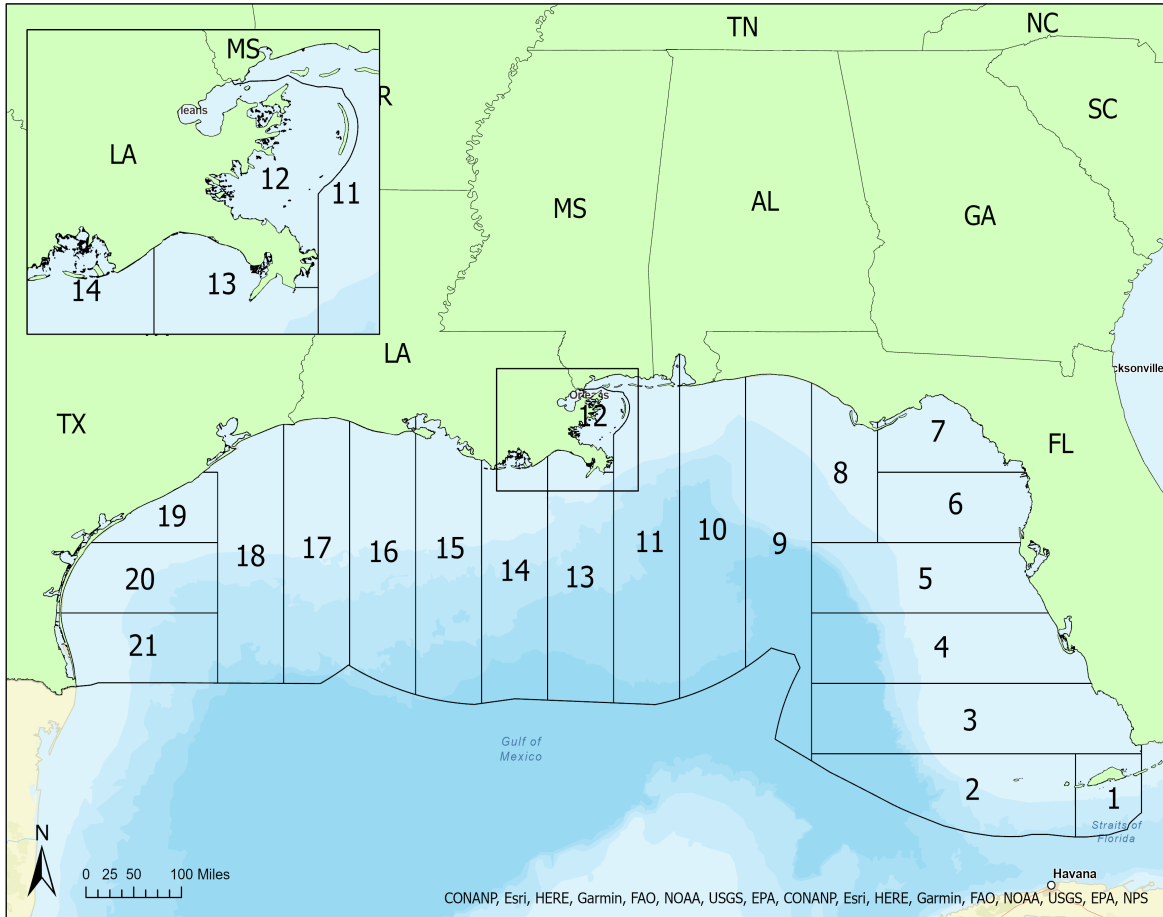
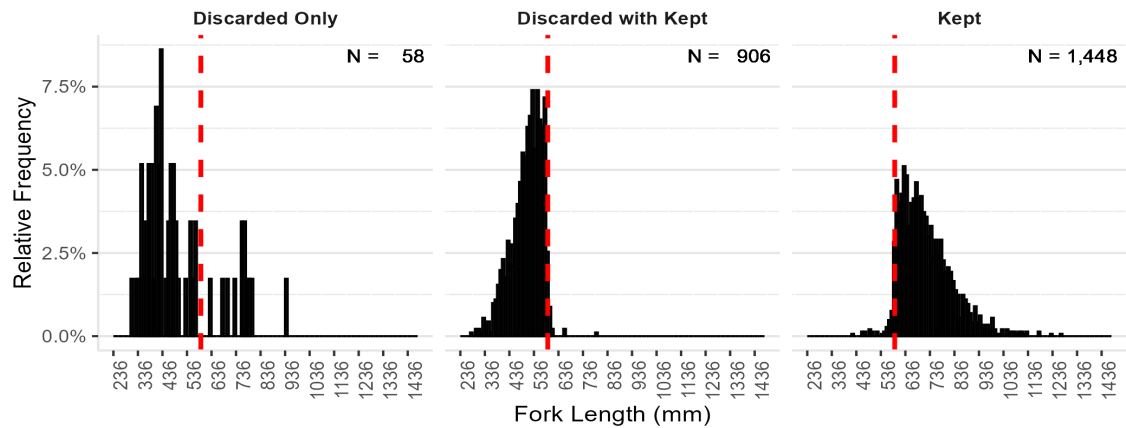


Figure 1. Map of fishing areas reported by observers.

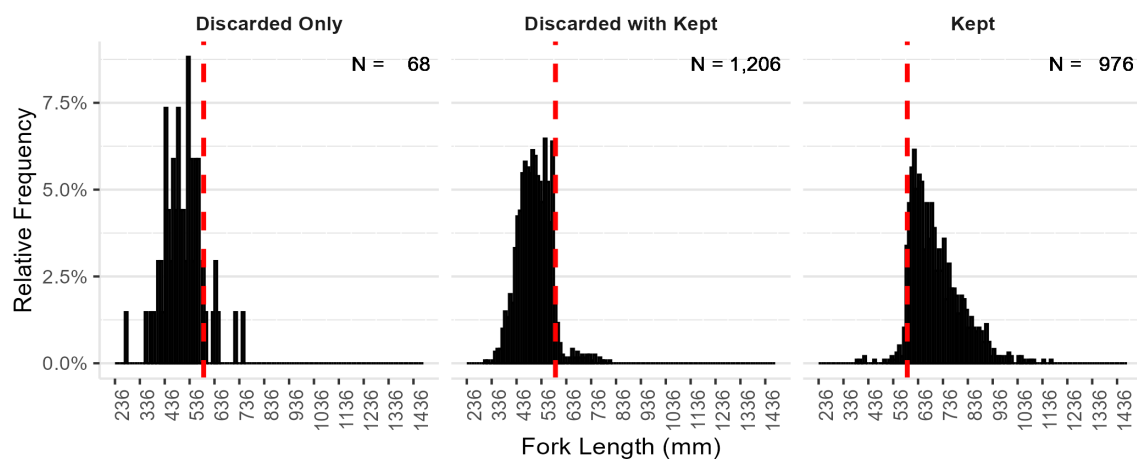
Pre-IFQ

Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)



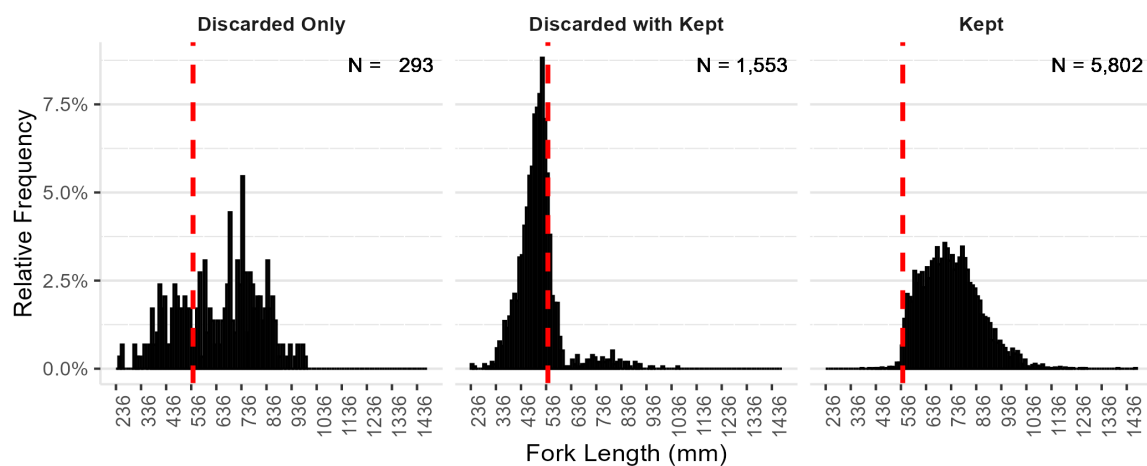
IFQ 2010-2011 24inTL

Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)

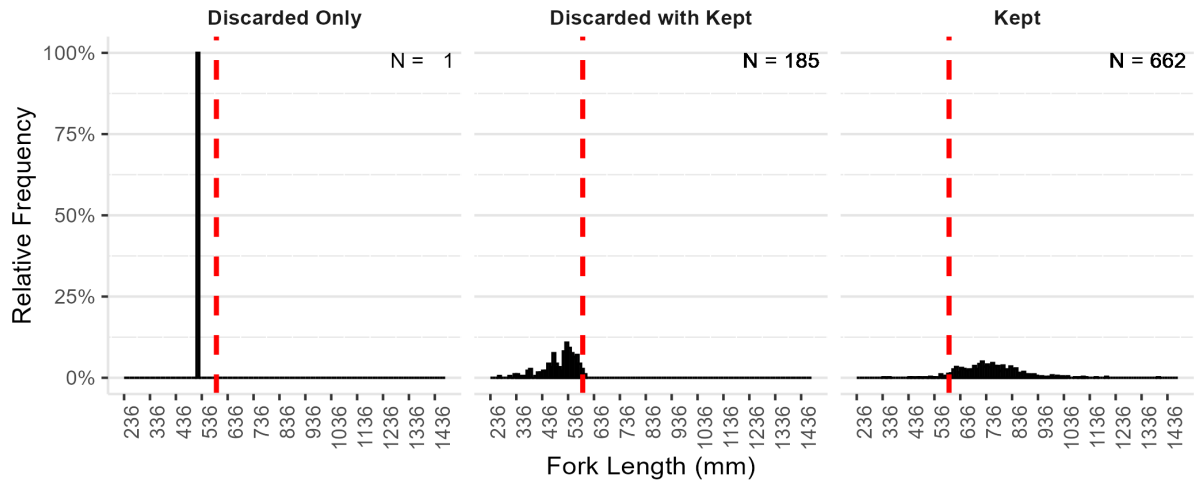


IFQ 2012-2018 22inTL

Min Size Limit = 22 inches Total Length (21.4 inches Fork Length)



IFQ 2019-2022 24inTL
 Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)



IFQ 2023-2024 24inTL
 Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)

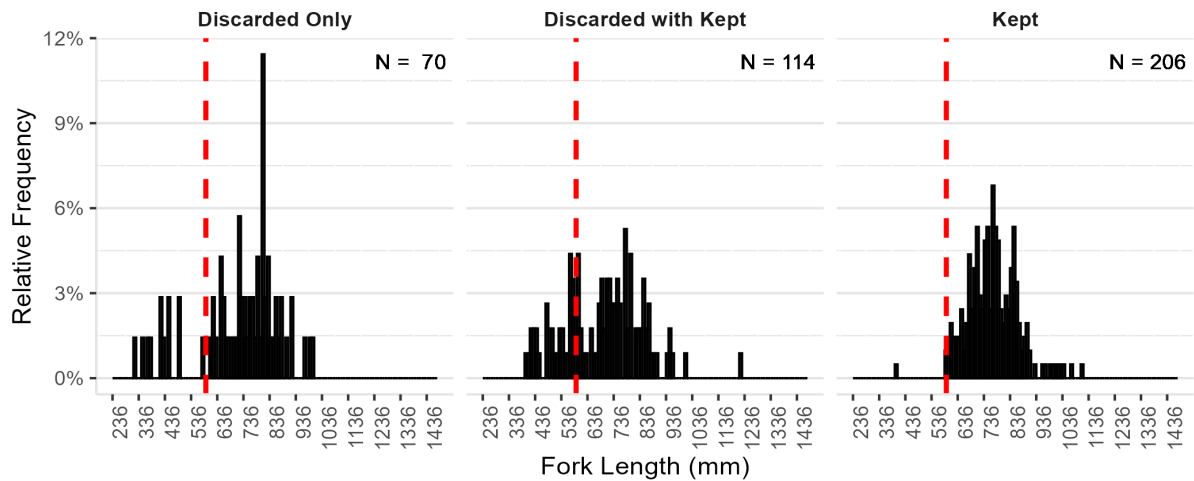


Figure 2. Length-frequency plots of observer vertical line Gulf of America Gag by disposition (Kept or Discard) and management regime. “Discarded Only” were discards from trips with no kept Gag; “Discarded with Kept” were discards from trips with kept Gag; and “Kept” is showing the length distribution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

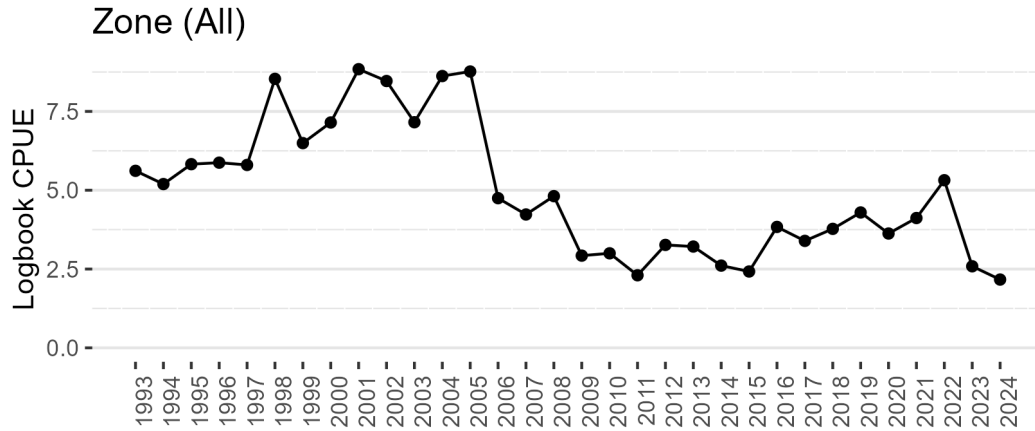


Figure 3. CPUE (catch in whole pounds per hour) time-series for logbook data from 1993 - 2024 for vertical line trips landing Gulf of America Gag.

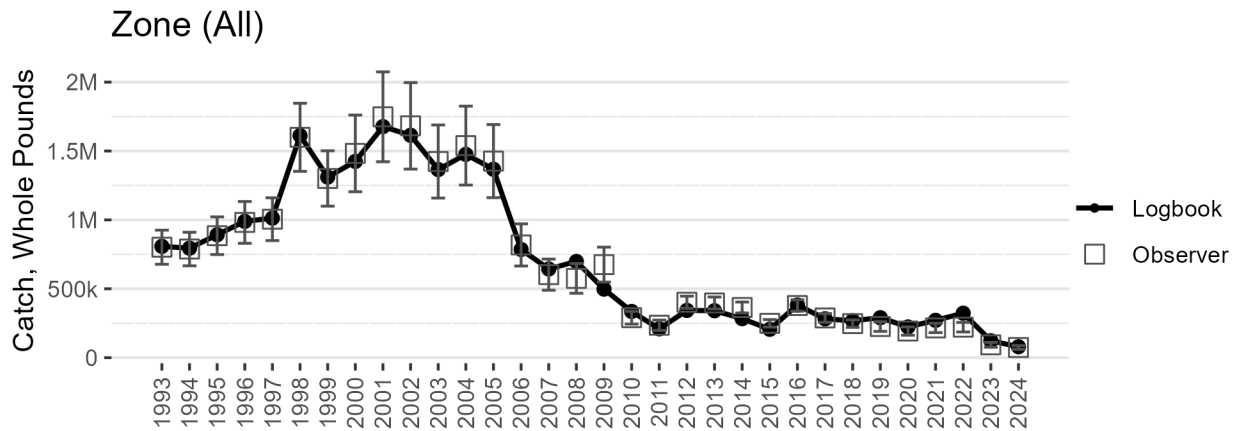
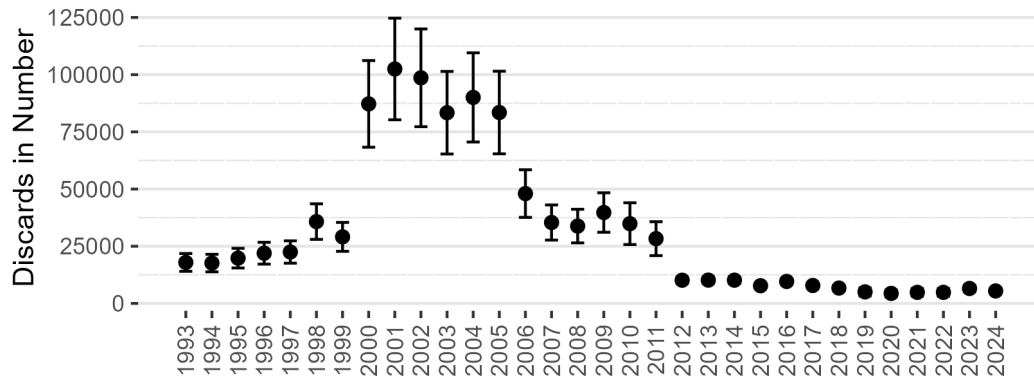


Figure 4. Comparison of vertical line reported annual logbook landings of Gulf of America Gag (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

(A) Discards in Number
Zone (All)



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

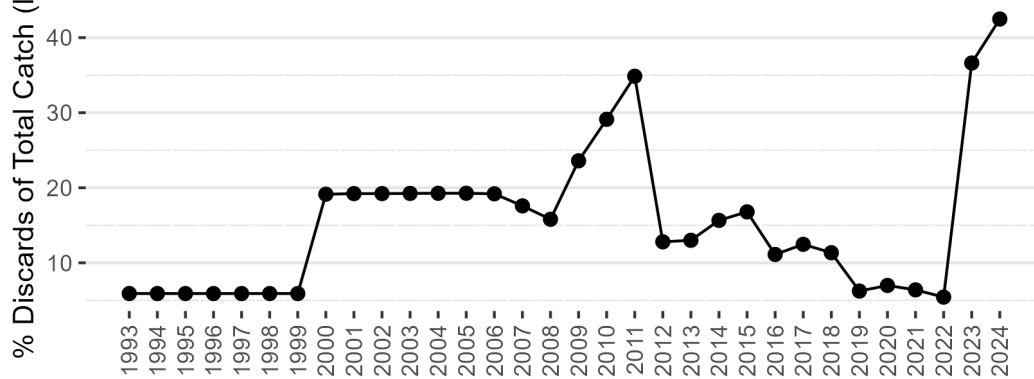


Figure 5. Observer CPUE expansion estimates of Gulf of America Gag commercial vertical line annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 1993 - 2024.

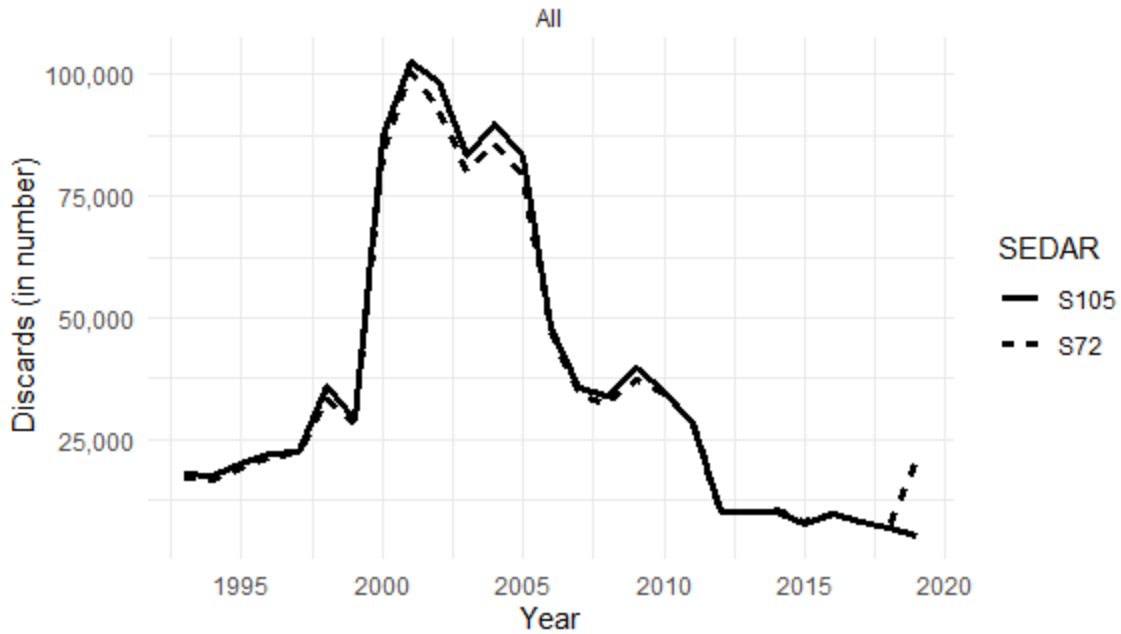


Figure 6. Commercial vertical line discard estimates of Gag for SEDAR 105 compared to SEDAR 72.

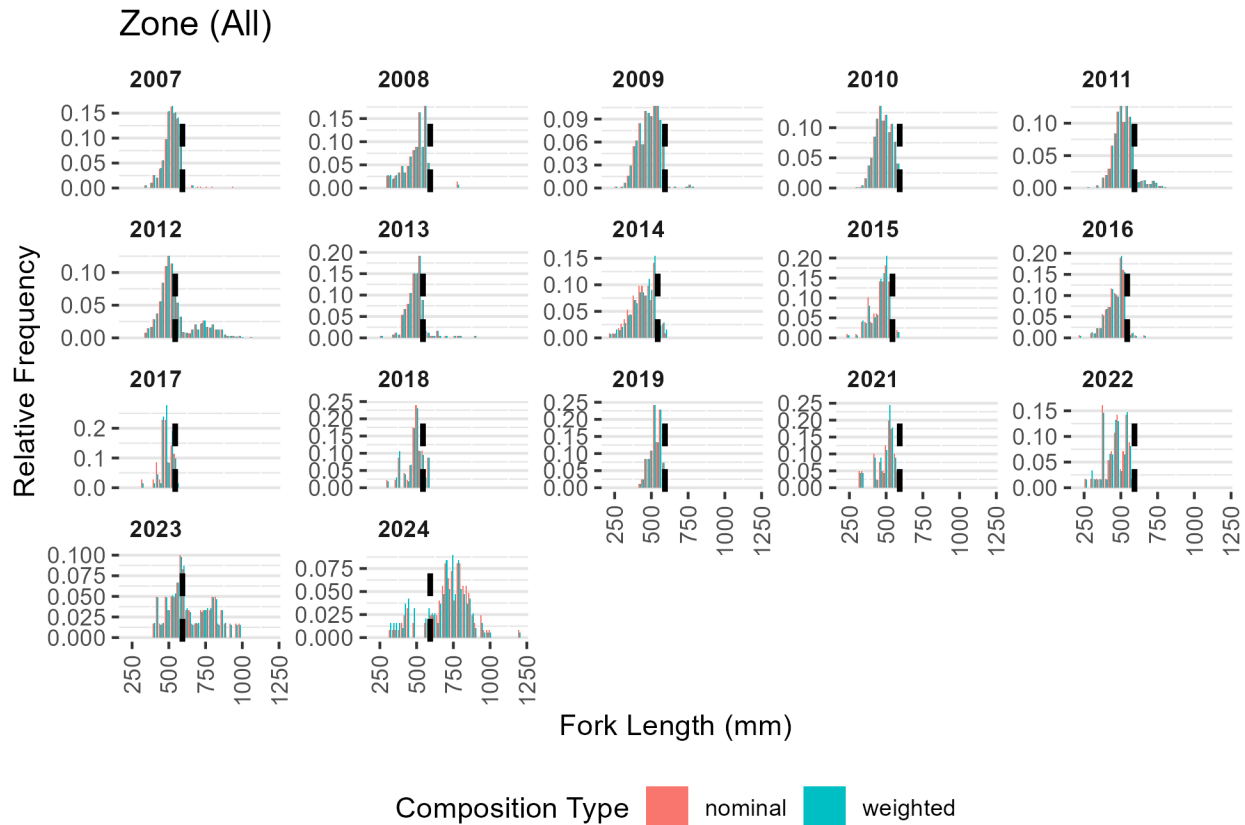
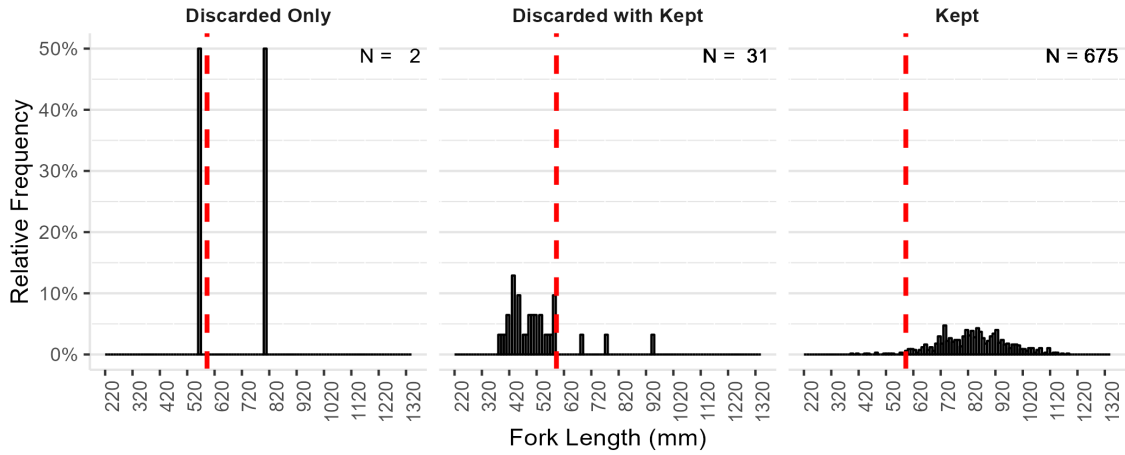
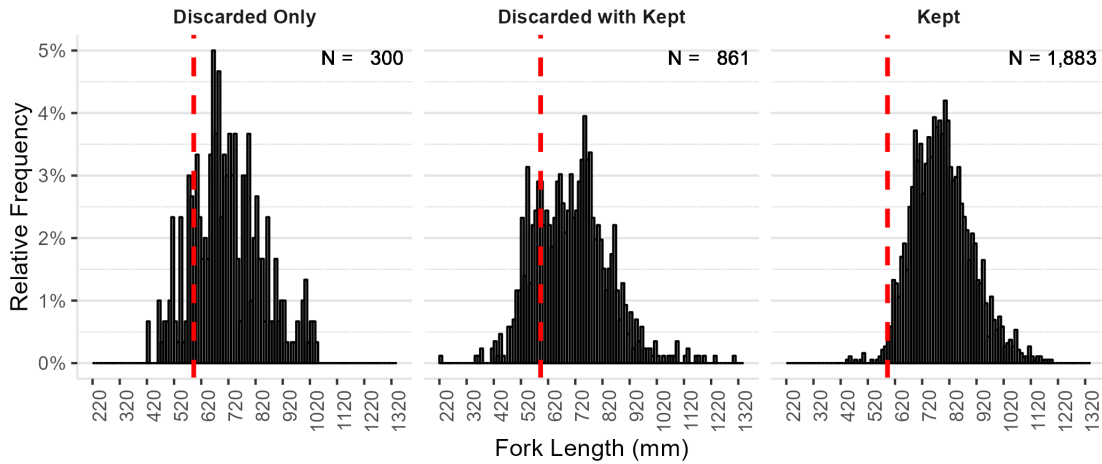


Figure 7. Commercial annual discard length compositions for Gulf of America Gag, accounting for catch and/or effort level stratification by management period.

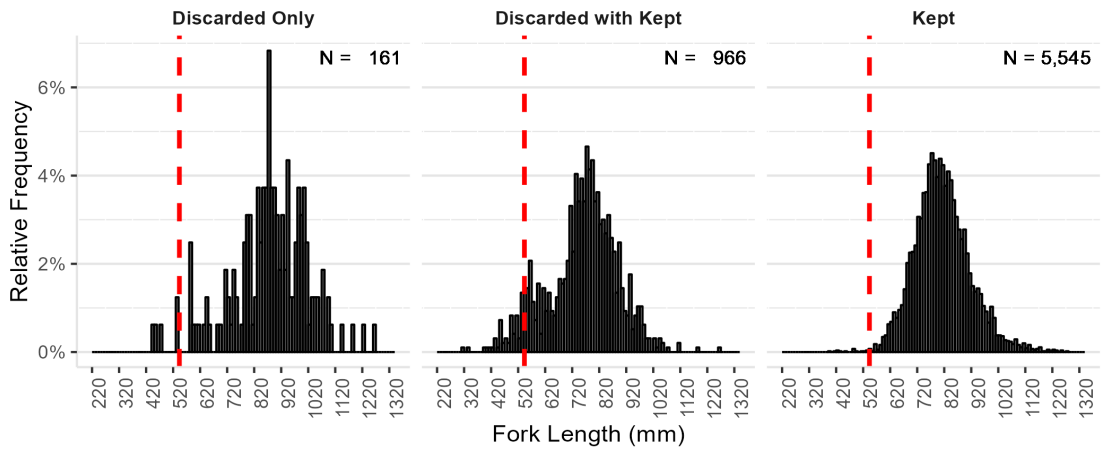
Pre-IFQ
 Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)



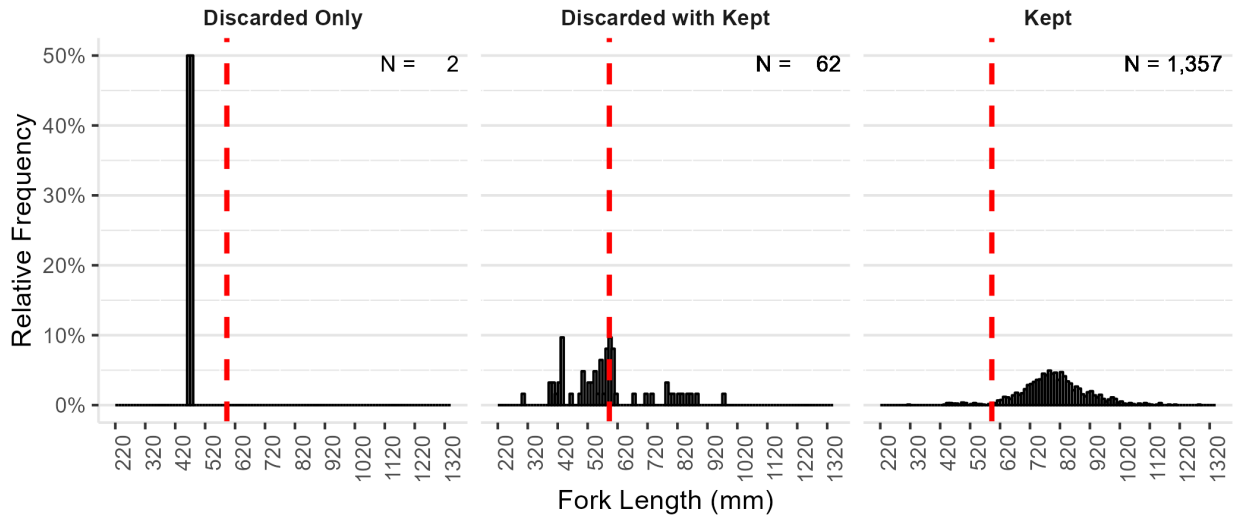
IFQ 2010-2011 24inTL
 Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)



IFQ 2012-2018 22inTL
 Min Size Limit = 22 inches Total Length (21.4 inches Fork Length)



IFQ 2019-2022 24inTL
 Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)



IFQ 2023-2024 24inTL
 Min Size Limit = 24 inches Total Length (23.3 inches Fork Length)

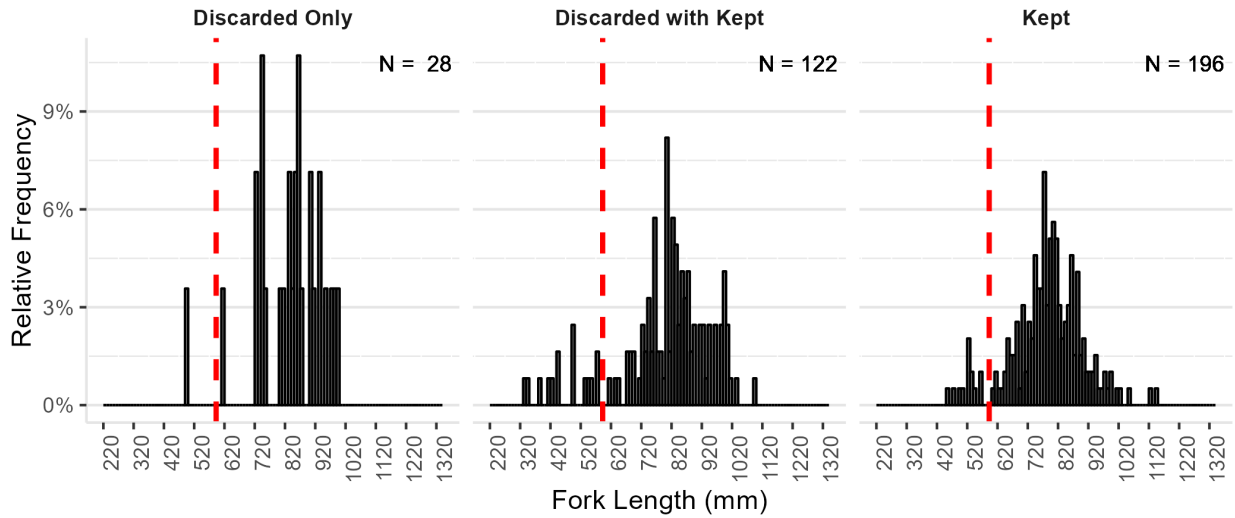


Figure 8. Length-frequency plots of observer bottom longline Gulf of America Gag by disposition (Kept or Discard) and management regime. “Discarded Only” were discards from trips with no kept Gag; “Discarded with Kept” were discards from trips with kept Gag; and “Kept” is showing the length distribution of the kept Gag only. Vertical dashed line denotes the minimum size limit in fork length (FL); N is the number of measured fish.

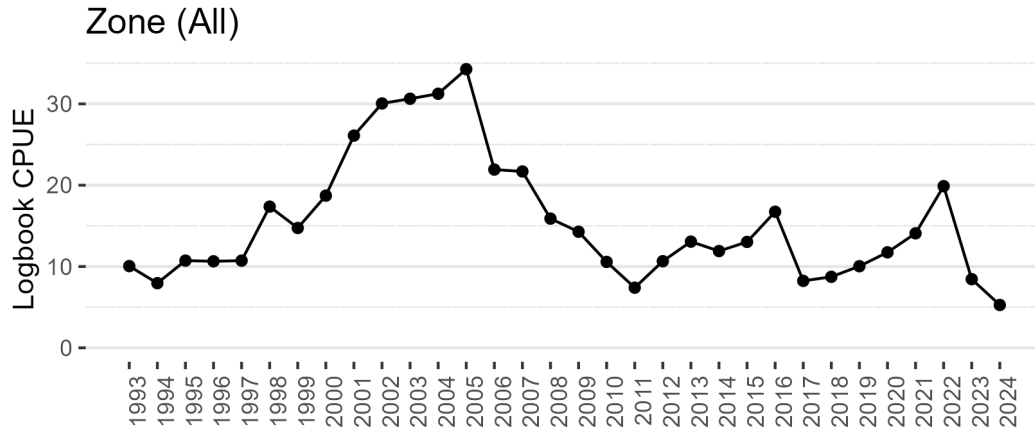


Figure 9. CPUE (catch in whole pounds per hour) time-series for logbook data from 1993 - 2024 for bottom longline trips landing Gulf of America Gag.

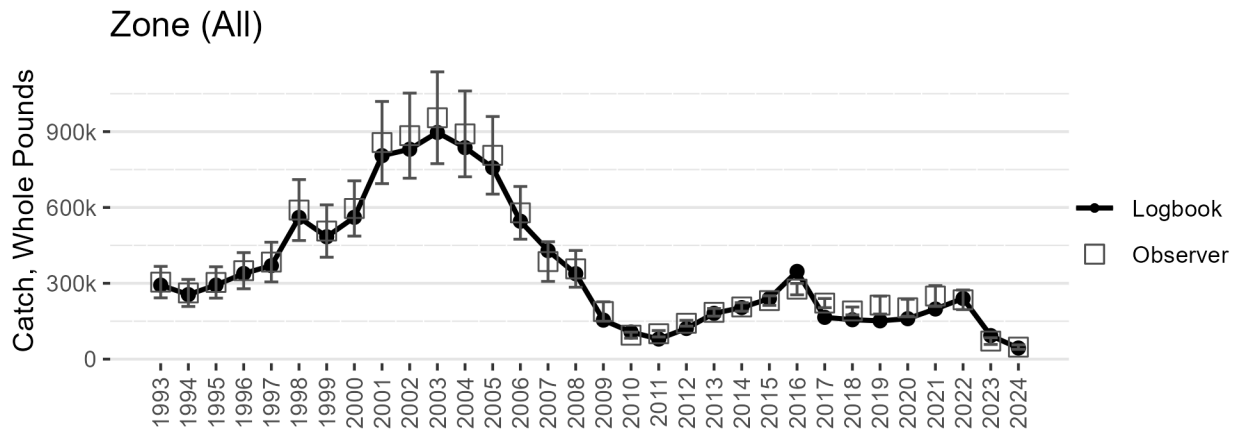
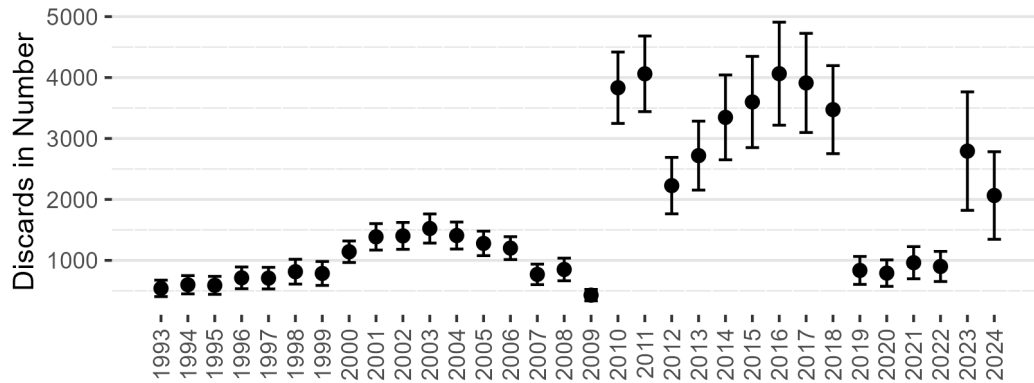


Figure 10. Comparison of bottom longline reported annual logbook landings of Gulf of America Gag (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

(A) Discards in Number
Zone (All)



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

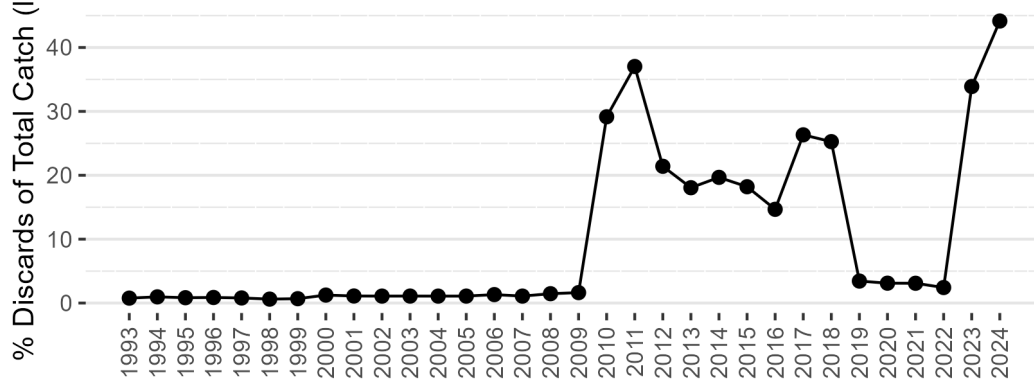


Figure 11. Observer CPUE expansion estimates of Gulf of America Gag bottom longline annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 1993 - 2024.

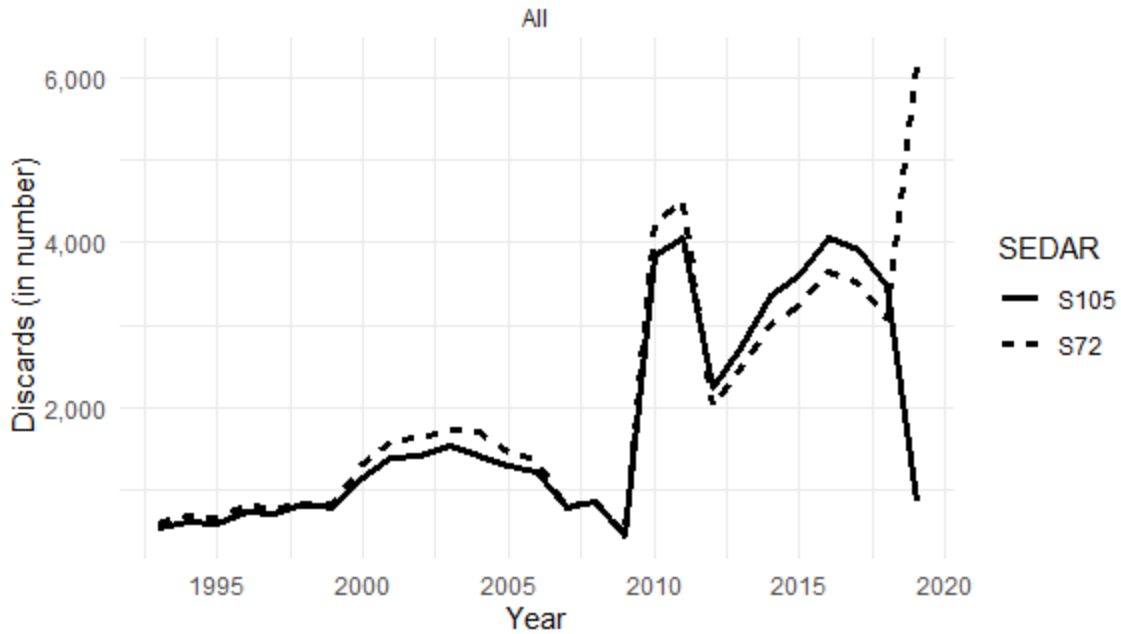


Figure 12. Commercial bottom longline discard estimates of Gag for SEDAR 105 compared to SEDAR 72.

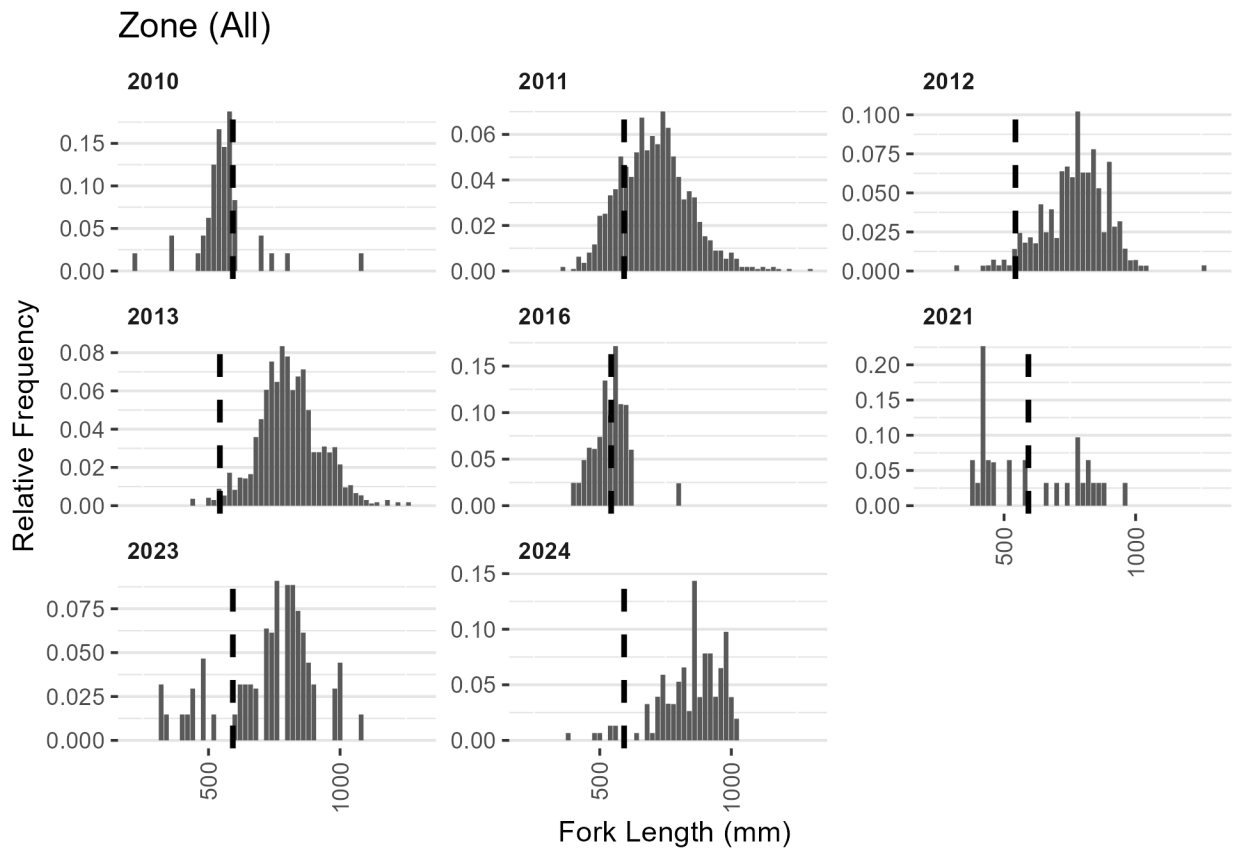


Figure 13. Commercial annual discard length compositions for Gulf of America Gag, accounting for catch and/or effort level stratification by management period.