CPUE Expansion Estimation for Commercial Discards of Gulf of America King Mackerel

Kevin Thompson, Sarina Atkinson, Gary Decossas

SEDAR99-WP-03

16 April 2026

Please cite this document as:

Thompson, Kevin, Sarina Atkinson, Gary Decossas. 2026. CPUE Expansion Estimation for Commercial Discards of Gulf of America King Mackerel. SEDAR99-WP-03. SEDAR, North Charleston, SC. 28 pp.

SEDAR 99 Working Paper

CPUE Expansion Estimation for Commercial Discards of Gulf of America King Mackerel

SEDAR99-WP-03

Kevin Thompson*[1], Sarina Atkinson[1], Gary Decossas[1]
April 2026

[1]National Marine Fisheries Service, Southeast Fisheries Science Center, Miami Laboratory, 75 Virginia Beach Drive, Miami, FL 33149

*Corresponding author: kevin.thompson@noaa.gov

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; Fig. 1) Red Grouper in SEDAR 61 (Smith et al. 2018), Gulf Gray Triggerfish in SEDAR 62 (Smith et al. 2019), and Gulf Vermilion Snapper in SEDAR 67 (Smith et al. 2019) to Gulf King Mackerel. Length compositions were also provided and followed the methods outlined in the same working papers.

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 coastal Reef Fish Observer Program began in July 2006; for Gulf King Mackerel discard estimation, complete calendars years 2007-2024 were used. Time periods for the methodology are 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 Gulf Reef fish permitted vessels in 1993. In 1998, King Mackerel permitted vessels were required to report. For this reason, Gulf King Mackerel discard estimation is limited to 1998 to 2024.

Relevant Management History of Gulf King Mackerel

For the period where King Mackerel discards are being estimated, there has been a minimum size limit of 24 inches fork length. There are also multiple area-specific closures and trip limits for Gulf King Mackerel. Due to the high frequency of these management changes, these regulations were excluded from the analysis. Specifically, the current discard estimation process

lacks the ability to apply differing management constraints to individual subregions simultaneously and we often lack the observer data to do so.

Gear

King Mackerel were observed on vertical line and trolling trips in the Gulf. For this assessment we independently estimated discards for both gears due to highly different catch rates and sample sizes, and ultimately combined these independent estimates into a single bycatch time series given the fleet structure of the assessment. While the assessment for this species includes a gillnet fishery, observer data remains limited for coastal migratory species in this fishery and as such we did not provide estimates for discards for that fishing sector.

King Mackerel Specific Data Processing

We estimated Gulf-wide King Mackerel discards using a few specific processing steps. First, we used all available observer data to calculate CPUE (Fig. 1). Next, we incorporated logbook data by pulling a subsample from the winter mixing zone and adding it to the Gulf logbook dataset. To handle the mixing zone split—where half the fish during the winter months are attributed to the South Atlantic stock and half to the Gulf—we randomly selected logbook trips from that area until we reached 50% of the total annual effort. The winter mixing zone was defined by landing date between November to March in logbook fishing area grids (2480-2483). We also defined the fishing year before starting the analysis: a year labeled as '2023' refers to the period from July 2023 through June 2024. This meant that any data with a landing date before July 1 was assigned to the previous fishing year to keep the timeline consistent. All analyses for Gulf King Mackerel are from 1998 to 2023 fishing year per the assessment TORs.

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 38U report. Additionally, when weight information was missing, the length-weight equation from the SEDAR 38U 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 $/hatC$ and associated variance followed procedures for a (Horvitz-Thompson) survey design ratio estimator (Jones et al. 1995; Lohr 2010):

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

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

Mean CPUE was estimated by

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

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

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

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

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

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

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

where the variance of mean CPUE is

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

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

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

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

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

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 King Mackerel. 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 King Mackerel. 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 $\widehat{Y_h}$.

$$\hat{Y}_h = C\bar{P}UE_h * \hat{X}_h$$

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

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

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

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

and then converted to relative proportion of length L,

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

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 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 King Mackerel. Trip selection in the observer program is set up for reef fish trips based on permits that vessels hold, as such King Mackerel is generally not the target species and the low sample sizes, particularly later in the time series, is reflective of that.

The disposition (kept or discarded) of Gulf King Mackerel showed some relationship to the minimum size limit of 24" FL (610 mm) (Fig. 2). Discards for trips where King Mackerel were retained were mostly undersized, however many above the limit fish were discarded in discard-only trips, indicating this reflects either vessels and trips with reef-fish permits that don't allow for King Mackerel retention or that were fishing during a closed season.

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips showed a generally increasing catch rate with a downturn in the last few years of the time series (Fig. 3) Catch-effort data for observer trips catching King Mackerel were stratified into two time periods (2007-2012 and 2013-2023 fishing years) due to changing catch rates over time. Due to limited sample sizes, two time periods were selected to ensure generally equal sample sizes of observer trips in each time period. Logbook catch-effort data for trips were pooled in the same manner. These observer and logbook datasets were the basis for subsequent analysis and estimation of catch and discards.

Analysis of catch between the observer and logbook datasets showed that observers sampled a higher proportion of low catch King Mackerel trips (Table 2). To account for this discrepancy, observer and logbook trips were grouped into strata according to low (L) and high (H) catches for subsequent analysis and estimation

The proportions of observer trips and effort encountering King Mackerel that had kept fish are given in Table 3 by time period and catch level strata. These proportions were used to adjust annual logbook total King Mackerel trips and effort (Table 4) to account for logbook trips that

only had discarded fish. Estimates of observer mean CPUE by time period and catch level strata are given in Table 5. These CPUEs were the basis for expansion estimates of King Mackerel catch and discards. Observer discard CPUEs for the first time period (2007-2012) were used in the hindcasting procedures.

CPUE expansion estimates of annual total landed catch of Gulf King Mackerel were generally less than the reported logbook landings with the greatest difference coming from the 2013-2014 time period (Fig. 4). From there the ability to expand to landings using observer CPUE starts to diverge with more differing values in the later part of the time series (Fig. 4). CPUE expansion estimates for annual discards in numbers and weight of Gulf King Mackerel are provided in Table 6. Estimated discards in number ranged from 200 to over 1000, depending on year. Discards in weight was under 5% of the total catch (kept + discards) for the time series and was generally under 2% with some years under 0.5% (Fig. 5B). Due to a consistent low bias in the catch verification from 2013 to 2023, calculated King Mackerel discards for the vertical line fleet are likely underestimated for this period.

Trolling

Significantly less trips were available in the observer database for trolling gear compared to stationary vertical line, as shown in Table 1. For this reason, observer and logbook datasets were pooled for the entire time series (2007-2023).

King Mackerel discards on trips with retained catch were predominantly undersized (below the 24-inch FL minimum size limit) (Fig. 6). In contrast, legal-sized discards occurred only on 'discard-only' trips, likely driven by regulatory constraints such as closed seasons or permit limitations.

Inspection of the annual nominal CPUE (catch in whole pounds per hour) from logbook trips reporting showed a relatively stable catch rate through time (Fig. 7), therefore no time periods breaks are needed. Analysis of effort? between the observer and logbook datasets showed that observers sampled a higher proportion of higher effort? King Mackerel trips (Table 7). To account for this discrepancy, observer and logbook trips were grouped into strata according to low (L) and high (H) catches for subsequent analysis and estimation.

The proportions of observer trips and effort encountering King Mackerel that had kept fish are given in Table 8 by effort level strata. These proportions were used to adjust annual logbook total King Mackerel trips and effort (Table 9) to account for logbook trips that only had discarded fish. Estimates of observer mean CPUE by time period and catch level strata are given in Table 10. These CPUEs were the basis for expansion estimates of King Mackerel catch and discards. Observer discard CPUEs for the entire time period were used in the hindcasting procedures due to low sample sizes.

CPUE expansion estimates of annual total landed catch of Gulf King Mackerel compared favorably with reported logbook landings (Fig 8), particularly compared to the same analyses for vertical line (Fig. 4). CPUE expansion estimates for annual discards in numbers and weight of Gulf King Mackerel for are provided in Table 11. Estimated discards in number ranged from 2-6

thousand fish per year. The very large SE values around these estimates are due to observer sample sizes. Discards in weight accounted was between 4-6.5% of the total commercial catch in the logbook (kept + discards) for the time series (Fig. 9B).

Combined estimates

Total combined discards for trolling and stationary vertical line are shown in Table 12. When compared to the same estimates presented and used in the previous SEDAR (38U), the updated numbers begin initially much lower than those used last time with agreement after 2010 (Fig. 10). The discard estimates from SEDAR 99 and SEDAR 38U are not truly comparable due to significant differences in CPUE data sources and the overall estimation methods. SEDAR 38U used SEFSC discard logbook data that the SEFSC no longer recommends (Alhale et al. 2024). The last few years of this time series shows a downturn in discards which is reflective of the generally declining landings of this species in more recent years (Fig. 10).

Literature Cited

Alhale, S., S. Atkinson, K. Thompson, G. Decossas, K. Dettloff. 2024. Reliability of the Discard Logbook for Use in Commercial Discard Estimates in the South Atlantic. SEDAR92-RD-05.

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.

Cochran, W.G. 1997. Sampling Techniques. 3rd Edition, John Wiley and Sons, NY.

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.

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. 2019a. Proposed CPUE Expansion Estimation for Total Discards of Gulf of Mexico Gray Triggerfish. SEDAR62-WP-07. SEDAR, North Charleston, SC. 21 pp.

Smith, S.G., A.C. Shideler, K.J. McCarthy. 2019b. CPUE Expansion Estimation for Total Discards of Gulf of Mexico Vermilion Snapper. SEDAR67-WP-12. SEDAR, North Charleston, SC. 21 pp.

Table 1. Number of total and vertical line (VL) and trolling (TR) trips by fishing year for the Gulf that observed King Mackerel (discarded and/or retained).

Fishing Year	Total Trips	King Mackerel Trips VL	King Mackerel Trips TR
2007	88	5	2
2008	52	6	0
2009	61	8	2
2010	43	0	2
2011	208	17	0
2012	181	23	1
2013	117	6	0
2014	151	5	2
2015	185	12	1
2016	101	8	1
2017	53	2	0
2018	24	0	0
2019	24	0	0
2020	31	0	0
2021	57	0	0
2022	46	0	0
2023	79	0	0

Table 2. Definition of trip catch level strata for Gulf King Mackerel, and corresponding percentages of logbook and observer vertical line trips for each zone and management regime.

					% Trips	
Zone	Management Regime	Season	Strata Level	Stratum Code	Logbook	Observer
All	First (2007-2012)	Open	Low, Catch <= 64 lbs	L	27.4	88.1
All	First (2007-2012)	Open	High, Catch > 64 lbs	H	72.6	11.9
All	Second (2013-2023)	Open	Low, Catch <= 253 lbs	L	38.8	81.8
All	Second (2013-2023)	Open	High, Catch > 253 lbs	H	61.2	18.2

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

						Proportion of Observer Data with Kept King Mackerel	
Zone	Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Trips	Effort
All	First (2007-2012)	Open	Catch	L	52	0.423	0.384
All	First (2007-2012)	Open	Catch	H	7	1	1
All	Second (2013-2023)	Open	Catch	L	27	0.296	0.224
All	Second (2013-2023)	Open	Catch	H	6	1	1

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

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2007	Open	Catch	L	444	1,049	13,980	36,450
2007	Open	Catch	H	748	748	13,552	13,552
2008	Open	Catch	L	451	1,066	14,070	36,686
2008	Open	Catch	H	910	910	15,792	15,792
2009	Open	Catch	L	319	754	10,264	26,762
2009	Open	Catch	H	874	874	14,827	14,827
2010	Open	Catch	L	256	605	7,088	18,481
2010	Open	Catch	H	733	733	11,394	11,394
2011	Open	Catch	L	224	529	5,090	13,272
2011	Open	Catch	H	759	759	10,984	10,984
2012	Open	Catch	L	226	534	5,889	15,355
2012	Open	Catch	H	1,061	1,061	15,593	15,593
2013	Open	Catch	L	444	1,498	8,174	36,503
2013	Open	Catch	H	702	702	11,069	11,069
2014	Open	Catch	L	508	1,714	9,828	43,890
2014	Open	Catch	H	853	853	13,412	13,412
2015	Open	Catch	L	442	1,492	6,834	30,519
2015	Open	Catch	H	700	700	11,433	11,433
2016	Open	Catch	L	524	1,768	8,362	37,345
2016	Open	Catch	H	784	784	11,888	11,888
2017	Open	Catch	L	583	1,968	9,612	42,923
2017	Open	Catch	H	962	962	13,210	13,210
2018	Open	Catch	L	480	1,620	6,081	27,156
2018	Open	Catch	H	725	725	8,532	8,532
2019	Open	Catch	L	433	1,461	6,294	28,108
2019	Open	Catch	H	675	675	7,532	7,532
2020	Open	Catch	L	472	1,593	7,014	31,325
2020	Open	Catch	H	742	742	7,972	7,972
2021	Open	Catch	L	364	1,228	5,043	22,521
2021	Open	Catch	H	457	457	4,798	4,798
2022	Open	Catch	L	272	918	4,502	20,105
2022	Open	Catch	H	523	523	5,356	5,356
2023	Open	Catch	L	295	996	5,152	23,008

					Logbook Trips		Logbook Effort
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2023	Open	Catch	H	481	481	5,226	5,226

Table 5. Estimated observer mean CPUE in weight by management regime and catch level strata for expansion estimates of vertical line Gulf King Mackerel catch and discards.

						Observer CPUE		
Zone	Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Kept	Discard (Weight)	Discard (Number)
All	First (2007-2012)	Open	Catch	L	0.341	0.127	0.177	0.017
All	First (2007-2012)	Open	Catch	H	48.966	40.924	0.100	0.029
All	Second (2013-2023)	Open	Catch	L	1.312	0.383	0.208	0.025
All	Second (2013-2023)	Open	Catch	H	72.799	38.538	0.257	0.025

Table 6. Time-series of CPUE expansion estimates for Gulf King Mackerel 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
1998	6,627	2,947	750	479
1999	6,582	2,842	784	475
2000	7,861	3,289	985	573
2001	7,734	3,158	1,009	572
2002	9,453	4,056	1,137	683
2003	6,921	2,837	897	511
2004	7,930	3,273	1,016	582
2005	6,149	2,487	814	459
2006	6,958	2,900	878	508
2007	7,810	3,765	1,023	798
2008	8,076	3,893	1,092	851
2009	6,221	2,999	892	696
2010	4,412	2,127	650	507
2011	3,448	1,662	548	427
2012	4,277	2,062	717	559
2013	10,436	3,706	1,194	325
2014	12,575	4,465	1,438	391
2015	9,285	3,297	1,053	287
2016	10,822	3,843	1,236	336
2017	12,322	4,375	1,409	383
2018	7,840	2,784	896	244
2019	7,782	2,763	895	243
2020	8,564	3,041	986	268
2021	5,918	2,101	686	187
2022	5,558	1,974	639	174
2023	6,129	2,176	709	193

Table 7. Definition of trip effort level strata for Gulf King Mackerel, and corresponding percentages of logbook and observer trolling trips for the 2007-2023 management regime.

Zone	Management Regime	Season	Strata Level	Stratum Code	% Trips	
					Logbook	Observer
All	All 2007-2023	Open	Low, Effort <= 28.27 hrs.	L	91.7	54.5
All	All 2007-2023	Open	High, Effort > 28.27 hrs.	H	8.3	45.5

Table 8. Gulf King Mackerel trolling trip and effort adjustment for the 2007-2023 management regime. Effort level strata are defined in Table 7. The proportions of King Mackerel observer trips and effort with kept King Mackerel were used to respectively adjust annual logbook total trips and effort (Table 9) to account for logbook trips that only had discarded fish.

Zone	Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept King Mackerel	
						Trips	Effort
All	All 2007-2023	Open	Effort	L	6	0.833	0.928
All	All 2007-2023	Open	Effort	H	5	1	1

Table 9. Annual time-series of trolling logbook trips (number) and effort (hours) by effort level strata for Gulf King Mackerel.

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2007	Open	Effort	L	774	929	8,797	9,475
2007	Open	Effort	H	94	94	3,319	3,319
2008	Open	Effort	L	841	1,009	8,336	8,979
2008	Open	Effort	H	69	69	2,486	2,486
2009	Open	Effort	L	826	991	8,620	9,284
2009	Open	Effort	H	81	81	3,081	3,081
2010	Open	Effort	L	929	1,115	8,806	9,485
2010	Open	Effort	H	34	34	1,230	1,230
2011	Open	Effort	L	928	1,114	9,946	10,713
2011	Open	Effort	H	81	81	3,073	3,073
2012	Open	Effort	L	1,141	1,369	10,922	11,764
2012	Open	Effort	H	103	103	4,106	4,106
2013	Open	Effort	L	974	1,169	10,351	11,149
2013	Open	Effort	H	110	110	4,396	4,396
2014	Open	Effort	L	929	1,115	10,025	10,798
2014	Open	Effort	H	153	153	5,981	5,981
2015	Open	Effort	L	1,077	1,292	12,278	13,224
2015	Open	Effort	H	113	113	4,099	4,099
2016	Open	Effort	L	1,219	1,463	13,550	14,594
2016	Open	Effort	H	129	129	4,765	4,765
2017	Open	Effort	L	1,341	1,609	13,082	14,090
2017	Open	Effort	H	125	125	4,732	4,732
2018	Open	Effort	L	1,076	1,291	11,354	12,229
2018	Open	Effort	H	92	92	3,355	3,355
2019	Open	Effort	L	1,040	1,248	11,513	12,400
2019	Open	Effort	H	51	51	1,954	1,954
2020	Open	Effort	L	971	1,165	10,018	10,790
2020	Open	Effort	H	69	69	2,516	2,516
2021	Open	Effort	L	634	761	6,892	7,423
2021	Open	Effort	H	40	40	1,446	1,446
2022	Open	Effort	L	623	748	6,355	6,845
2022	Open	Effort	H	47	47	1,738	1,738
2023	Open	Effort	L	612	734	6,043	6,509

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2023	Open	Effort	H	44	44	1,711	1,711

Table 10. Estimated observer mean CPUE in weight by management regime and effort level strata for expansion estimates of trolling Gulf King Mackerel catch and discards.

						Observer CPUE		
Zone	Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Kept	Discard (Weight)	Discard (Number)
All	All 2007-2023	Open	Effort	L	76.229	81.753	4.928	0.989
All	All 2007-2023	Open	Effort	H	53.445	51.034	0.249	0.071

Table 11. Time-series of CPUE expansion estimates for Gulf King Mackerel trolling 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
1998	33,796	27,880	6,842	5,546
1999	33,492	27,417	6,802	5,455
2000	43,273	35,477	8,783	7,058
2001	45,349	37,078	9,215	7,378
2002	44,277	36,353	8,981	7,232
2003	43,252	35,661	8,758	7,094
2004	39,136	32,195	7,932	6,405
2005	39,439	32,603	7,977	6,485
2006	48,253	39,669	9,783	7,892
2007	47,520	40,062	9,603	8,025
2008	44,868	37,827	9,053	7,566
2009	46,521	39,220	9,397	7,854
2010	47,048	39,665	9,465	7,910
2011	53,557	45,153	10,809	9,033
2012	58,995	49,737	11,921	9,963
2013	56,036	47,242	11,334	9,472
2014	54,700	46,116	11,099	9,275
2015	66,188	55,801	13,364	11,169
2016	73,105	61,633	14,766	12,340
2017	70,613	59,532	14,265	11,922
2018	61,101	51,512	12,328	10,303
2019	61,597	51,930	12,398	10,362
2020	53,801	45,358	10,846	9,064
2021	36,939	31,143	7,441	6,219
2022	34,164	28,803	6,890	5,758
2023	32,502	27,401	6,556	5,479

Table 12. Time-series of CPUE expansion estimates for Gulf King Mackerel for combined vertical line and trolling 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
1998	40,423	28,035	7,592	5,567
1999	40,074	27,564	7,586	5,476
2000	51,134	35,629	9,768	7,082
2001	53,084	37,212	10,223	7,400
2002	53,730	36,578	10,118	7,264
2003	50,173	35,773	9,655	7,112
2004	47,067	32,361	8,948	6,431
2005	45,588	32,698	8,792	6,501
2006	55,211	39,774	10,660	7,908
2007	55,330	40,239	10,626	8,065
2008	52,944	38,027	10,145	7,614
2009	52,742	39,335	10,290	7,884
2010	51,460	39,722	10,114	7,926
2011	57,005	45,183	11,357	9,043
2012	63,272	49,779	12,638	9,978
2013	66,472	47,387	12,528	9,477
2014	67,274	46,331	12,537	9,284
2015	75,473	55,898	14,417	11,172
2016	83,927	61,753	16,002	12,345
2017	82,935	59,692	15,674	11,928
2018	68,941	51,588	13,224	10,306
2019	69,378	52,004	13,293	10,364
2020	62,365	45,460	11,832	9,068
2021	42,857	31,213	8,127	6,221
2022	39,722	28,870	7,529	5,761
2023	38,630	27,487	7,265	5,483

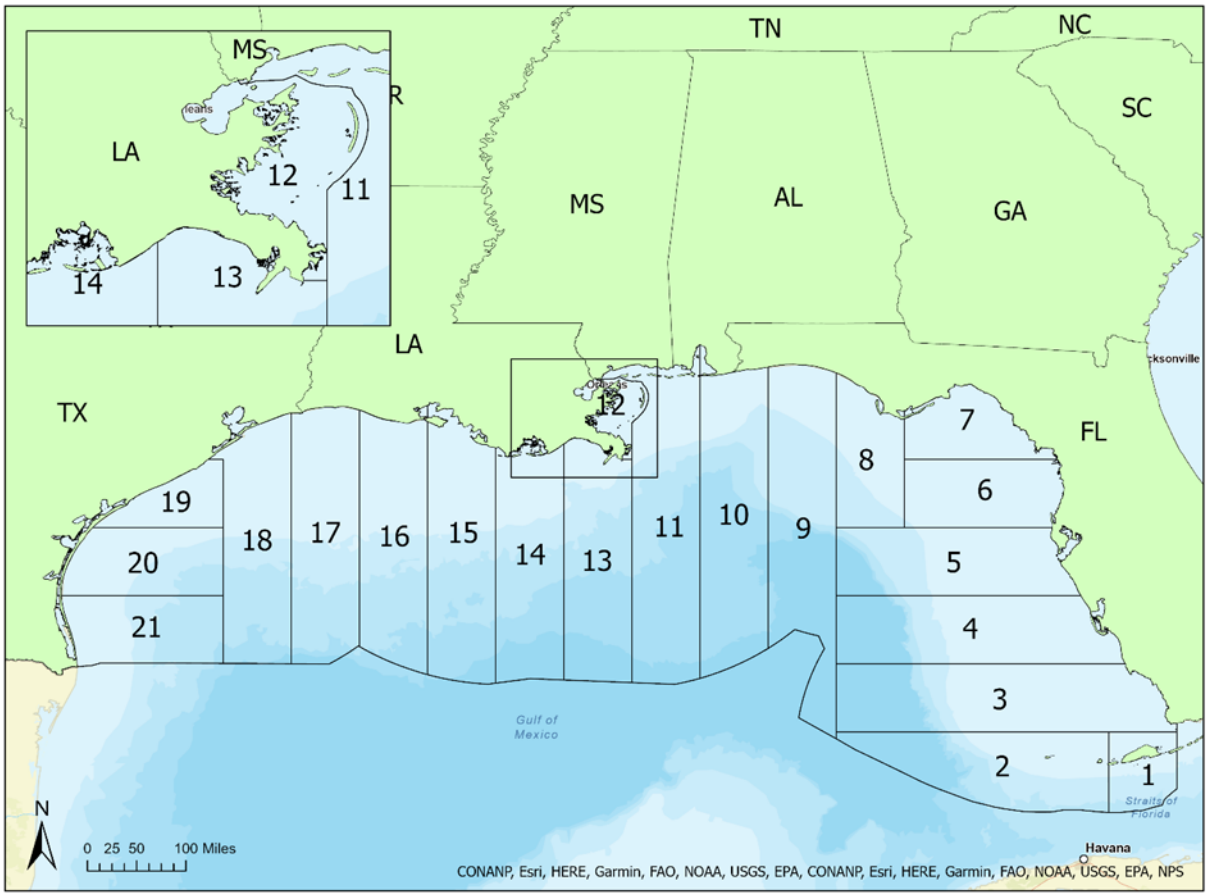


Figure 1. Map of Gulf observer fishing areas.

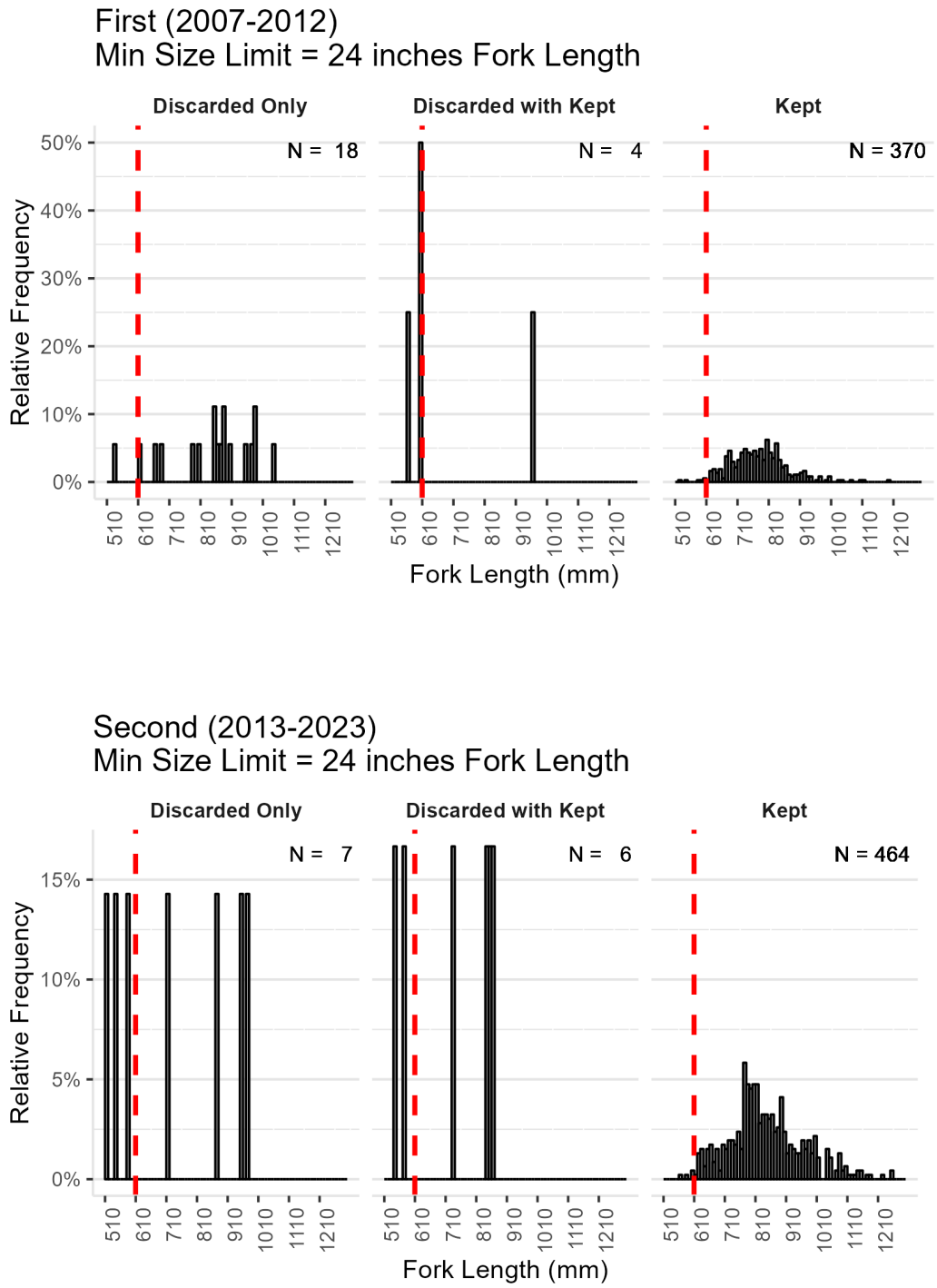


Figure 2. Length-frequency plots of observer vertical line Gulf King Mackerel by disposition (Kept or Discard) and management regime. "Discarded Only" were discards from trips with no kept King Mackerel; "Discarded with Kept" were discards from trips with kept King Mackerel. "Kept" …?….Vertical dashed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

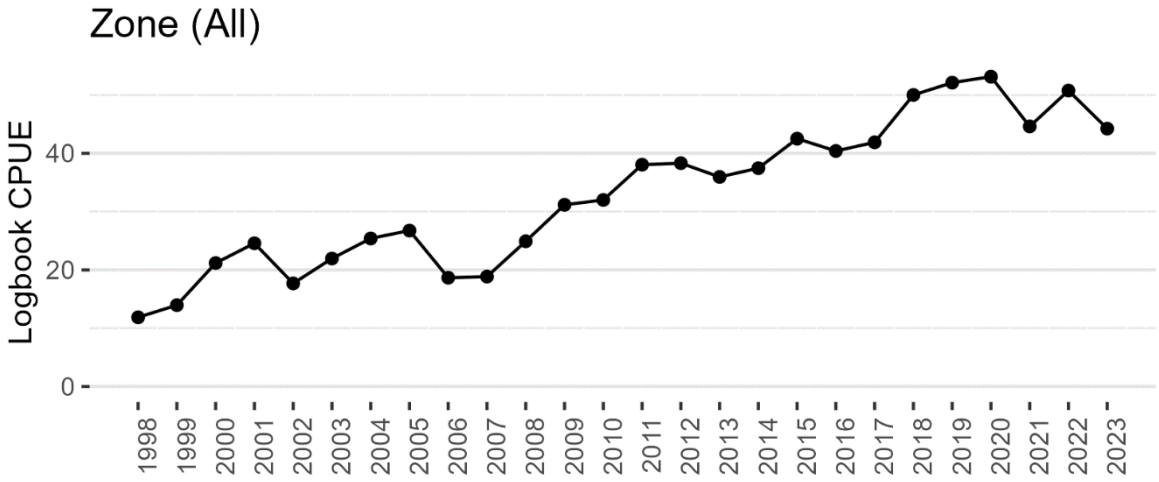


Figure 3. CPUE (catch in whole pounds per hour) time-series for logbook data from 1998 - 2023 for vertical line trips landing Gulf King Mackerel.

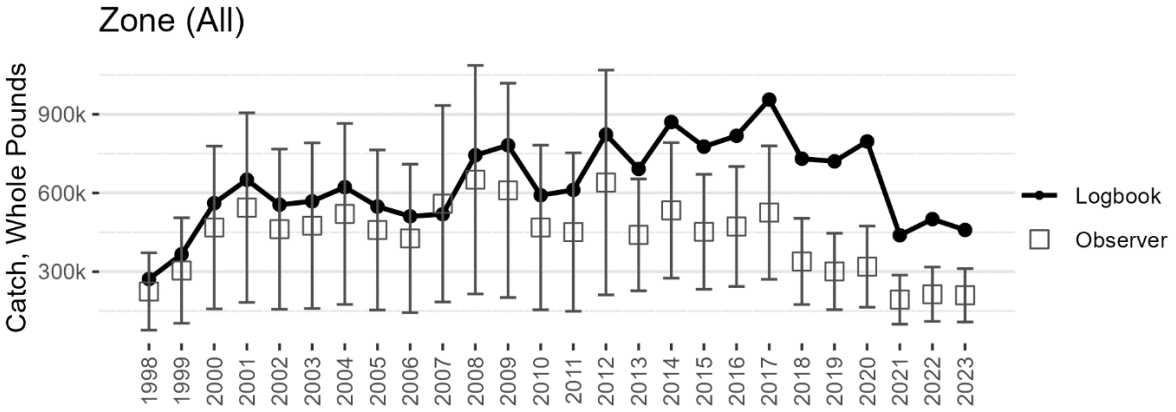
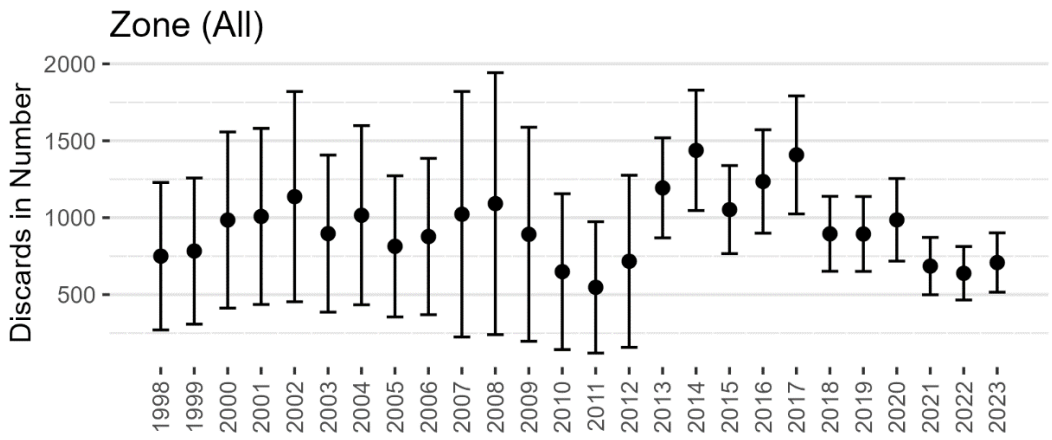


Figure 4. Comparison of vertical line reported annual logbook landings of Gulf King Mackerel (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch

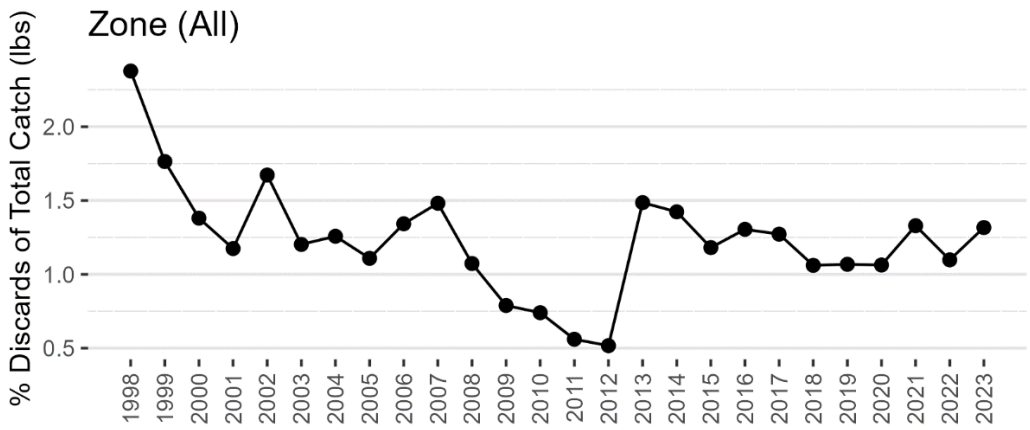


Figure 5. Observer CPUE expansion estimates of Gulf King Mackerel commercial vertical line annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 2007 - 2023.

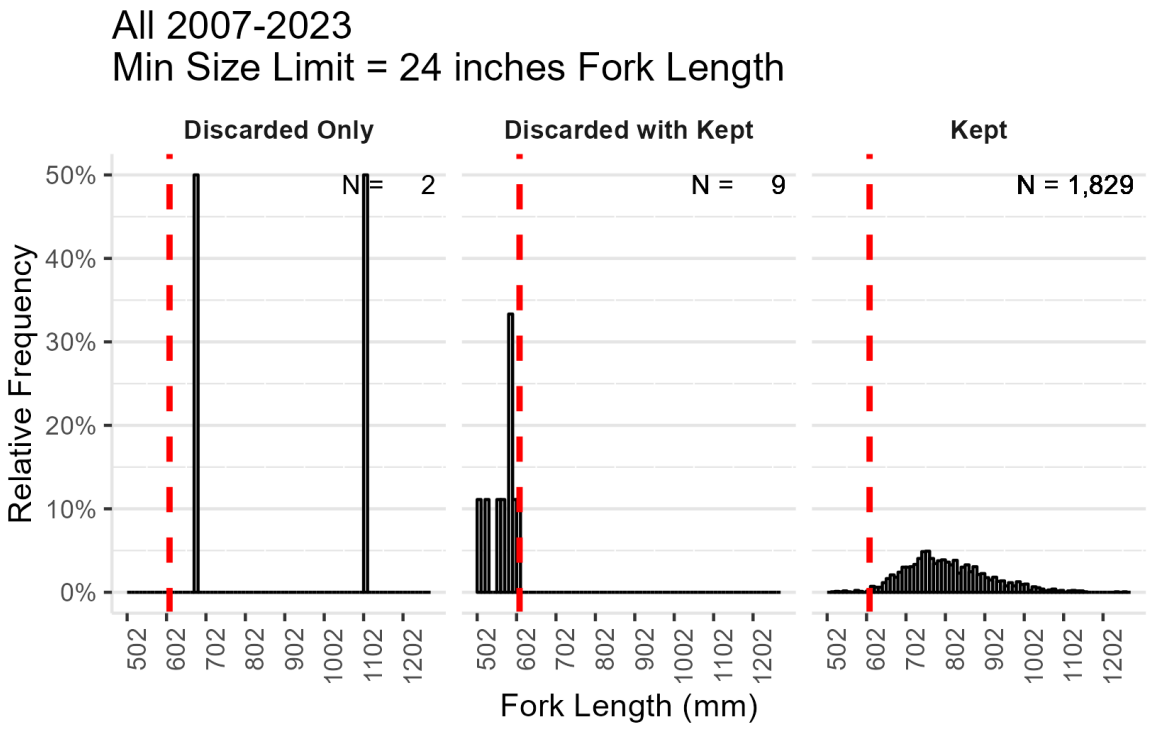


Figure 6. Length-frequency plots of observer trolling Gulf King Mackerel by disposition (Kept or Discard) and management regime. "Discarded Only" were discards from trips with no kept King Mackerel; "Discarded with Kept" were discards from trips with kept King Mackerel. Vertical dashed line denotes the minimum size limit in fork length (FL); N is the number of measured fish.

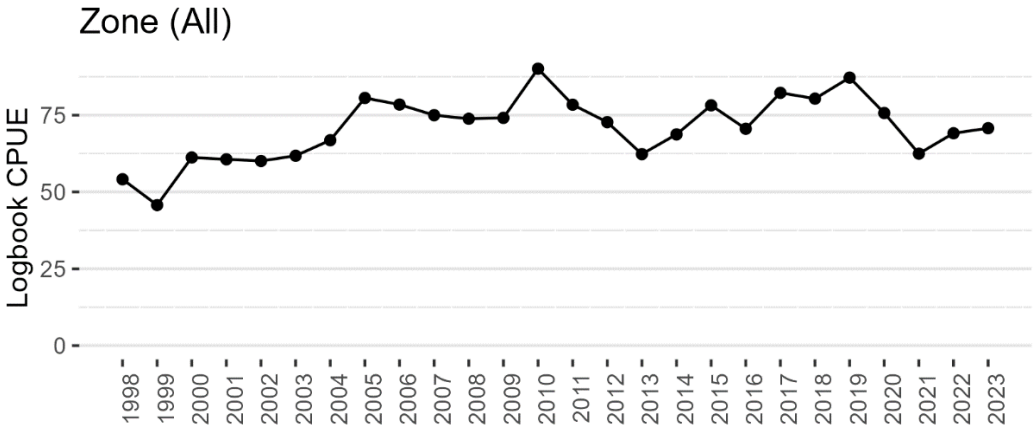


Figure 7. CPUE (catch in whole pounds per hour) time-series for logbook data from 1998 - 2023 for trolling trips landing Gulf King Mackerel.

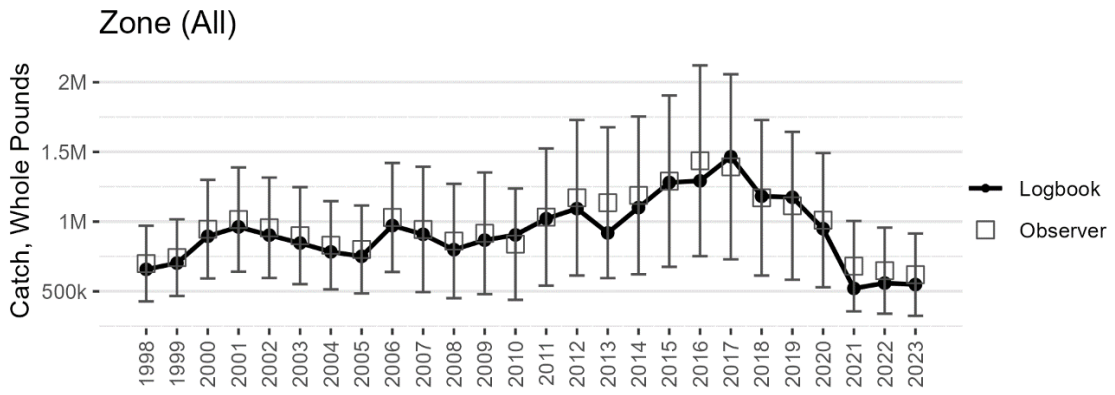
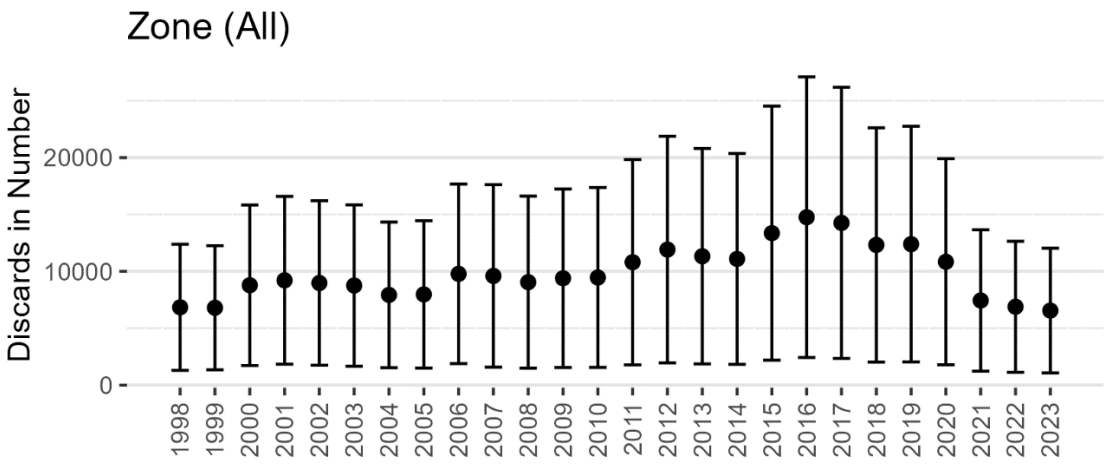


Figure 8. Comparison of trolling reported annual logbook landings of Gulf King Mackerel (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch

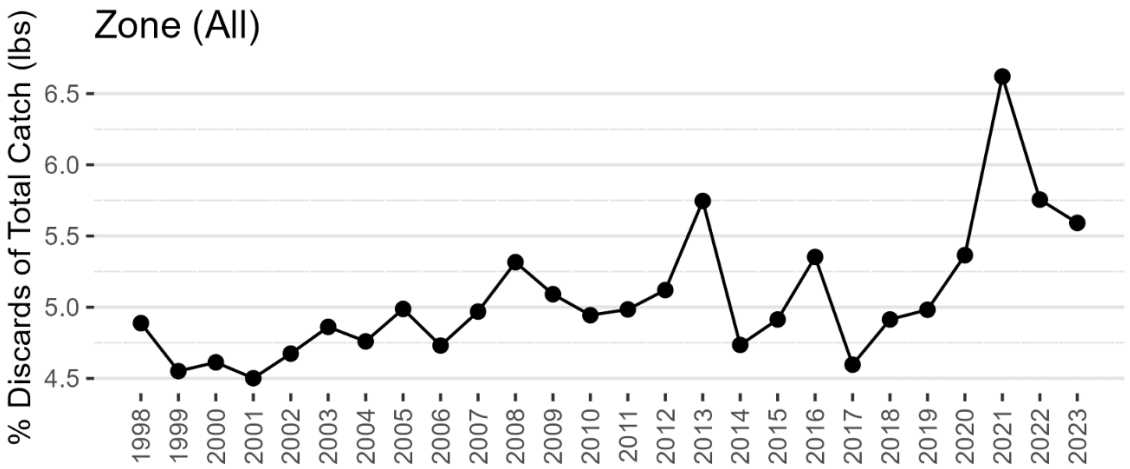


Figure 9. Observer CPUE expansion estimates of Gulf King Mackerel commercial trolling annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 1998 - 2023.

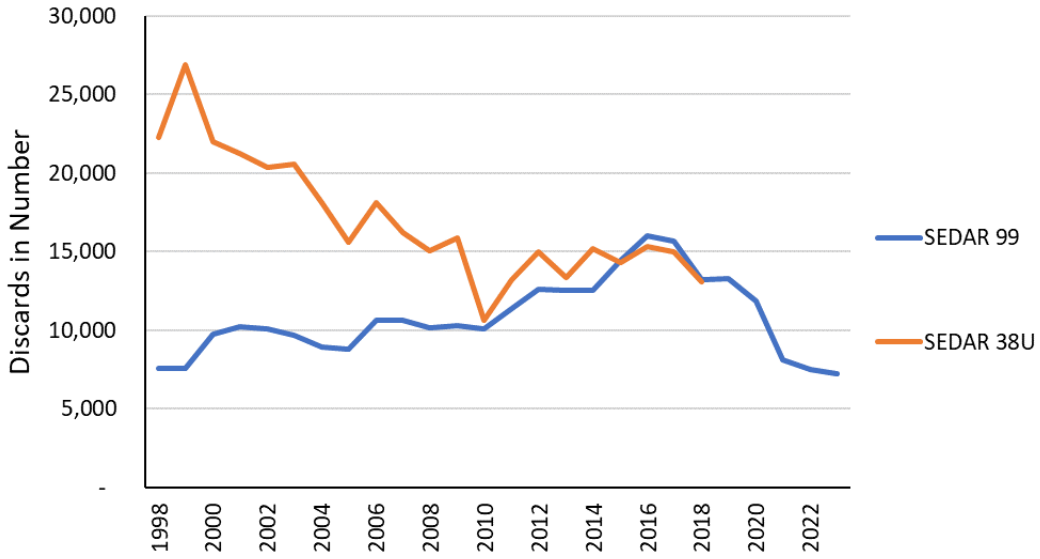


Figure 10. Comparison of updated discards in number for combined trolling and vertical line for King Mackerel to the last SEDAR (38U).