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CPUE Expansion Estimation for Commercial Discards of South Atlantic Red Snapper

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April 2025

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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 analysis was to apply the discard estimation methods developed for Gulf of America Red Grouper in SEDAR 61 (Smith et al. 2018), Gulf of America Gray Triggerfish in SEDAR 62 (Smith et al. 2019), and Gulf of America Vermilion Snapper in SEDAR 67 (Smith et al. 2019) to South Atlantic Red Snapper. Overall, the discard estimation methods developed using Gulf of America data suited South Atlantic Red Snapper with the exception of the closed season. Therefore, different approaches were explored specifically for estimating closed season discards.

Methods

Data Sources

Vertical line observer data were collected by the Gulf and South Atlantic Fisheries Foundation (GSAFF) from 2007-2016 and the Southeast Fisheries Science Center (SEFSC) from 2014-2021. Data collected by GSAFF target vessels with valid Snapper-Grouper permits exclusively fishing bandit reels. Fishers voluntarily participated in the project and were compensated for each day an observer was aboard a vessel. Additionally, one crew member may have been displaced to allow space for the observer during the fishing trip (GSAFF, 2008). Mandatory observer coverage began in 2014 under a Marine Fisheries Initiative (MARFIN) grant which funded 62 sea days from February 2014 through January 2015 (Enzenauer et al. 2015). Beginning in 2018, the SEFSC South Atlantic Reef Fish Observer Program has continuous mandatory coverage for the vertical line portion of the South Atlantic reef fish fishery. Decossas & Mathers (2023) documents in more detail vessel selection for this program with the main difference being a crew member is not displaced. All observer data from 2007-2023 were considered for estimating discards of South Atlantic Red Snapper.

For both observer programs, scientific observers on commercial fishing vessels record detailed information on catch and effort for a subset of trips. Catch by species was recorded according to the 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. 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 (CFLP) in which fishers reported basic information on effort and catch by species for every trip (Atkinson et al. 2021). The coastal logbook program began in 1990 for a subset of vessels in Florida and

expanded to all vessels in 1993. For South Atlantic Red Snapper discard estimation, complete calendar years 1993-2023 were considered.

Relevant Management History of South Atlantic Red Snapper

There were several key management changes relevant to discard estimation:

(1) A 20-inch total length minimum size limit established in 1992 until the end of 2009. Starting in 2010, there is no Red Snapper minimum size limit.

(2) A series of closures first established in 2010 that would close the South Atlantic Red Snapper fishery for the majority of the year. Table 1 highlights the number of days the fishery was open and closed in a given year from 2010-2023.

(3) A 50-pound gutted weight trip limit implemented in 2012 which was increased to 75 pounds in 2013. Given these regulations, two management regimes were defined for the observer time period, the pre-closure period (2007-2009) and the closure period (2010-2023).

Gear

For the South Atlantic region, observer data only sampled vertical line (handline and electric reel) trips. Therefore, discard estimation for Red Snapper was conducted for only this gear.

Spatial Domain

Per recommendation of the stock assessment analysts, discard estimates were conducted for the South Atlantic, defined in Figure 1. The South Atlantic stock boundary is based on fishing area from the Florida Keys (South of US 1) to the North Carolina and Virginia border. Fishing areas that span the NC/VA border are included.

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 the logbook data (Smith et al. 2018).

Catch Expansion Procedures and Verification

Observer CPUE was calculated using trip-level nominal effort and catch of kept Red Snapper for a given time period. Statistical estimation of total catch $\hat{C}$ and associated variance followed procedures for a (Horvitz-Thompson) survey design ratio estimator (Jones et al. 1995; Lohr 2010):

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

where $C\bar{P}UE$ is observer mean CPUE and $\hat{X}$ is total logbook nominal effort. Species-specific logbook total effort $\hat{X}$ for vertical lines was calculated in two steps. First, logbook trip effort for vertical lines was summed over trips reporting landings of Red Snapper. 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

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

Using the kept observer CPUE, 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. Since total logbook nominal effort, $\hat{X}$, starts with trips reporting landings of Red Snapper, this catch expansion procedure was only applicable when estimating Red Snapper discards for the open season.

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 Red Snapper. 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 Red Snapper. 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). The pre-closure management regime (2007-2009) was used in the hindcast procedure to estimate discards from 1993-2006 because these data were collected when the same 20-inch minimum total length size limit was in effect. 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 Estimation for the Red Snapper Closed Season

The standard catch expansion procedures described above were unsuitable when applied to the closed season because logbook effort $\hat{X}$ is underestimated, given the fishery is closed the majority of the year starting in 2010. As a result, different approaches were explored to capture logbook effort during the closed season when Red Snapper are not targeted. Species assemblages

have been analyzed in the South Atlantic reef fish fishery to inform possible species likely caught in the same habitat that Red Snapper exist (Shertzer & Williams 2008).
Utilizing a similar analysis to Shertzer and Williams (2008), two analyses were performed:

1) Non-multidimensional scaling (ordination; NMDS)
2) Non-hierarchal, agglomerative clustering

Landings data (whole pounds of fish caught) used in the analysis were collected from the commercial sector via the CFLP from 2010-2023. Analyses of commercial data were restricted to trips that occurred in the South Atlantic with handline and electric-line gear, and also included single-day and multi-day trips. This is in contrast to Shertzer and Williams (2008), which used only handline, single day trips from 1992-2006 (where 2006 was a partial year). That paper used those data filters because, at the time, handline gear accounted for 87% of the records, while single-day trips accounted for 50% of the records. However, for the 2010-2023 time period, this pattern does not hold as handline gear only accounts for 67% of records and single-day trips account for more than half the trips in the South Atlantic.

For the NMDS and cluster analysis, the Bray-Curtis measure of dissimilarity (i.e. distance) between species was used as it was also used by Shertzer and Williams (2008). The format of the matrix used to compute dissimilarities is the same as well with rows representing species and columns representing vessel-months (i.e. the sum of landings for a vessel in a month). Species were removed if they appeared in fewer than 1% of all trips because rare and incidental species may distort ordination patterns (McCune & Grace 2004). In addition, data were transformed with the root-root (fourth root) transformation to moderate the influence of abundant species.

The NMDS analysis was performed in RStudio using the *ecodist* (v2.1.3; Goslee & Urban 2007) and *vegan* (v2.6.10; Oksanen et al. 2025) libraries, while the k-medoid method of non-hierarchal cluster analysis was performed using the *pam* function found in the *cluster* (v2.1.8.1; Maechler et al. 2025) library. The optimal number of clusters were determined by looking at the average silhouette width for a range of chosen *k* clusters.

Discard Length Composition

The length frequency distributions for discards were estimated using 30 millimeter (mm) maximum total length bins, labelled at the midpoint. Nominal relative proportion of length bin (L) was computed as

$$L_i = \frac{n_i}{\sum n_i}$$

Where n_i is the number of discarded fish in a given year i.

Results and Discussion

There is a total of 265 Red Snapper trips observed from 2007-2023. These trips are summarized in Table 2 by observer program where the sampling design differs. Inspection of the annual

nominal CPUE (catch in whole pounds per hour) from logbook trips reporting Red Snapper showed a fairly stable trend from 1993-2007, followed by an increasing average CPUE from 2008-2023 (Fig. 2). Considering management history, observer sampling program methodologies across time, and observer sample sizes, initial management regimes are pre-closure (2007-2009) and closure time periods (2010-2023).

Discards were mostly fish near or below the minimum size limit during the pre-closure period 2007-2009, and kept fish were mostly above the minimum size limit. Discard estimation was conducted separately within the pre-closure 2007-2009, closure period 2010-2023 open season and closure period 2010-2023 closed season management regimes to account for potential changes in the discard CPUE indicated by differences in the discard length frequencies and discard behavior. Observer data from the pre-closure period (2007-2009) were used for hindcasting discards for the pre-observer years 1993-2006, which had the same minimum size limit (20" TL). Catch-effort data for observer trips catching Red Snapper were pooled across years for the respective management regimes. Logbook catch-effort data for Red Snapper trips were pooled in the same manner. These observer and logbook datasets were the basis for subsequent analysis and estimation of catch and discards for the pre-closure and closure management regimes.

Observer and logbook frequency distributions of trip-level catch, effort, and CPUE were similar for closure period (2010-2023), suggesting that observer sampling of Red Snapper trips in the open season was representative of the commercial fleet. This was not the case for years 2007-2009 (pre-closure management regime). Further analysis showed that observers sampled a higher proportion of high effort (> 75 hours) Red Snapper trips relative to the commercial fleet (Table 3). To account for this discrepancy, observer and logbook trips were grouped into strata according to low (L) and high (H) effort for subsequent analysis and estimation.

CPUE expansion estimates of annual total landed catch of South Atlantic Red Snapper compared favorably with reported logbook landings for 1993-2023 (Fig. 3). However, due a sharp decline in Red Snapper landings in 2010 caused by near year-round closures, two alternative methods or calculating logbook total effort to estimate discards were explored. For the open season, the proportions of observer trips and effort encountering Red Snapper that had kept fish are given in Table 4 by management regime and effort level strata. These proportions were used to adjust annual logbook total Red Snapper trips and effort (Table 5) to account for logbook trips that only had discarded fish.

For the closed season, discards appear to be from non-Red Snapper targeted trips. This is evident spatially in the observer data where a majority of the landed catch and discards during the open season are off the coast of Florida. However, during the closed season, discarded effort of Red Snapper shifts to North Carolina, South Carolina, and Georgia waters. Therefore, logbook effort used in the expansion needed to account for trips targeting other species within Red Snapper habitat.

Our analysis adopted from Shertzer & Williams (2008) and described in the methods section, indicated that the patterns in species assemblages are still roughly the same as the 1992-2006 time period, with there being three main assemblages: Northern Assemblage, Southern

Assemblage, and Deepwater Assemblage (Fig. 4). The Northern Assemblage is associated with Red Snapper and includes 18 other species. Table 6 lists the species part of the North Assemblage from our analysis and the 10 of which also appear on the list generated by Shertzer and Williams (2008). The annual logbook trips and effort for the closed season (Table 7) is derived from sub-setting the logbook data to trips that caught at least one of the species listed in Table 6.

Estimates of observer mean CPUE by management regime and effort level strata for the open season are given in Table 8. These CPUEs were the basis for expansion estimates of Red Snapper catch and discards during the open season. Observer discard CPUEs for the pre-closure management regime (2007-2009) were the basis for hindcasting discards during 1993-2006. Observer discard CPUEs for the closed season was further divided into two time periods given high sample sizes during the closed season. These time periods were guided by observer sampling program changes with 2010-2017 indicating a time when there was GSAFF sampling and the start of SEFSC collecting observer data in the South Atlantic. The second time period (2018-2023) indicates the well-established SEFSC South Atlantic Reef Fish Observer Program. Observer discard CPUEs in number and weight for the closed season are given in Table 9.

CPUE expansion estimates for annual discards in numbers and whole weight of South Atlantic Red Snapper for 1993-2023 are provided in Table 10. Total estimated discards in number ranged from 8,000 to 19,000 fish during the pre-closure management regime 1993-2009, and averaged about 23,000 fish during the closure management regime 2010-2023 (Fig. 5A). When the season is open, discards in weight accounted for about 30% of the total catch (kept + discards). Open season discards are largely a result of the 50-pound gutted weight trip limit. Combined open and closed season discards account for over 50% of the total catch in years when the fishery is open for a few months (Fig. 5B). Annual nominal discard length frequencies in 30 mm maximum total length bins are provided in Figure 6. Years with less than 3 trips observed are excluded for confidentiality.

The previous South Atlantic Red Snapper assessment (SEDAR 73) utilized discard logbook data and method adopted from SEDAR 41 for estimating discards (McCarthy 2015). For SEDAR 73, an annual nominal discard rate by open and closed season was calculated using discard logbook data from 2002-2019. A weighted mean discard rate using 2002-2009 (open season) data was used for hindcasting 1992-2001. The discard rate was weighted by the number of discard logbook trips reporting either Red Snapper or no discards for that year. These discard rates were applied to a filtered logbook dataset that represented an estimate of total effort. Estimates from each assessment cannot be directly compared because the methodology for estimating total effort and the source of the discard rates differ. However, SEDAR 90 and SEDAR 73 annual estimated commercial discards are shown in Figure 7 with overall similar magnitude.

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Table 1. Number of days the South Atlantic Red Snapper fishery was open and closed each year from 2010-2023.

Year	Days Open	Days Closed
2010	3	362
2011	0	365
2012	25	341
2013	44	321
2014	58	307
2015	0	365
2016	0	365
2017	60	305
2018	116	249
2019	53	312
2020	53	312
2021	69	296
2022	51	314
2023	43	322

Table 2. Number of total and Red Snapper South Atlantic observer vertical line trips by year and data collection time period.

Observer Program & Data Collection Entity	Year	Total Trips	Red Snapper Trips
Gulf and South Atlantic Fisheries Foundation (GSAFF) voluntary participation	2007	28	15
	2008	5	4
	2009	7	6
	2010	6	3
	2011	13	10
	2014	5	3
	2015	24	20
	2016	16	13
Southeast Fisheries Science Center MARFIN grant	2014	26	9
	2015	1	1
Southeast Fisheries Science Center South Atlantic Reef Fish Observer Program	2018	18	3
	2019	12	7
	2020	16	5
	2021	55	19
	2022	282	106
	2023	208	56

Table 3. Definition of trip catch level strata for South Atlantic Red Snapper, and corresponding percentages of logbook and observer vertical line trips for each zone and management regime.

Management Regime	Season	Strata Level	Stratum Code	% Trips	
				Logbook	Observer
Pre-closure 2007-2009	Open	Low, Effort <= 75 hours	L	84	54.5
Pre-closure 2007-2009	Open	High, Effort > 75 hours	H	16	45.5

Table 4. South Atlantic Red Snapper vertical line trip and effort adjustment factors by management regime and catch level strata. Catch level strata are defined in Table 3; catch level stratum 'All' is all levels (i.e., no stratification) for the management regime. The proportions of Red Snapper observer trips and effort with kept Red Snapper were used to respectively adjust annual logbook total trips and effort (Table 5) to account for logbook trips that only had discarded fish.

Management Regime	Season	Strata Type	Strata Level	Number of Observer Trips (n)	Proportion of Observer Data with Kept Red Snapper	
					Trips	Effort
Pre-closure 2007-2009	Open	Effort	L	12	0.75	0.743
Pre-closure 2007-2009	Open	Effort	H	10	1	1
Closures 2010-2024	Open	All	A	123	0.984	0.924

Table 5. Annual time-series of vertical line logbook trips (number) and effort (hours) by effort level strata for South Atlantic Red Snapper during the open season only.

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
1993	Open	Effort	L	2,031	2,708	57,999	78,026
1993	Open	Effort	H	280	280	27,491	27,491
1994	Open	Effort	L	2,196	2,928	62,376	83,914
1994	Open	Effort	H	299	299	29,774	29,774
1995	Open	Effort	L	2,015	2,687	61,042	82,120
1995	Open	Effort	H	223	223	21,081	21,081
1996	Open	Effort	L	1,742	2,323	51,800	69,687
1996	Open	Effort	H	254	254	24,436	24,436
1997	Open	Effort	L	1,463	1,951	39,717	53,431
1997	Open	Effort	H	224	224	21,806	21,806
1998	Open	Effort	L	1,393	1,857	34,809	46,828
1998	Open	Effort	H	192	192	18,809	18,809
1999	Open	Effort	L	1,363	1,817	34,391	46,266
1999	Open	Effort	H	171	171	16,364	16,364
2000	Open	Effort	L	1,261	1,681	33,089	44,515
2000	Open	Effort	H	165	165	15,478	15,478
2001	Open	Effort	L	1,734	2,312	45,560	61,291
2001	Open	Effort	H	274	274	27,895	27,895
2002	Open	Effort	L	1,801	2,401	46,937	63,144
2002	Open	Effort	H	307	307	31,796	31,796
2003	Open	Effort	L	1,108	1,477	32,190	43,305
2003	Open	Effort	H	291	291	29,131	29,131
2004	Open	Effort	L	1,079	1,439	33,442	44,989
2004	Open	Effort	H	199	199	19,299	19,299
2005	Open	Effort	L	1,013	1,351	32,013	43,067
2005	Open	Effort	H	171	171	16,533	16,533
2006	Open	Effort	L	763	1,017	21,838	29,378
2006	Open	Effort	H	215	215	21,904	21,904
2007	Open	Effort	L	865	1,153	24,077	32,391
2007	Open	Effort	H	243	243	23,846	23,846
2008	Open	Effort	L	1,183	1,577	32,122	43,213
2008	Open	Effort	H	210	210	20,484	20,484
2009	Open	Effort	L	1,380	1,840	32,736	44,040

				Logbook Trips		Logbook Effort	
Year	Season	Strata Type	Strata Level	Reported	Adjusted (N)	Reported	Adjusted ($\hat{X}$)
2009	Open	Effort	H	202	202	19,975	19,975
2010	Open	All	A	10	10	301	326
2012	Open	All	A	82	83	1,610	1,742
2013	Open	All	A	350	356	6,731	7,282
2014	Open	All	A	824	838	13,299	14,389
2017	Open	All	A	961	977	7,759	8,395
2018	Open	All	A	1,551	1,577	19,436	21,028
2019	Open	All	A	1,415	1,438	13,480	14,585
2020	Open	All	A	1,387	1,410	14,790	16,001
2021	Open	All	A	1,374	1,397	13,803	14,934
2022	Open	All	A	1,218	1,238	12,024	13,010
2023	Open	All	A	1,154	1,173	10,371	11,221

Table 6. South Atlantic species assemblage containing Red Snapper using 2010-2023 coastal logbook data for the updated analysis compared to the Shertzer & Williams (2008) analysis.

Common Name		Species ITIS Code
Updated Analysis	Shertzer & Williams (2008)	
Greater Amberjack		168689
Black Sea Bass	Black Sea Bass	167687
Gag Grouper	Gag Grouper	167759
Red Grouper	Red Grouper	167702
White Grunt	White Grunt	613026
Red Hind		167700
Rock Hind		167696
Hogfish		170566
Almaco Jack		168691
Margate	Margate	169060
Jolthead Porgy		169197
Knobbed Porgy		169201
Red Porgy	Red Porgy	169207
Banded Rudderfish		168693
Scamp	Scamp	167763
Red Snapper	Red Snapper	168853
Silk Snapper		168861
Vermilion Snapper	Vermilion Snapper	168909
Gray Triggerfish	Gray Triggerfish	173138

Table 7. Annual time-series of vertical line logbook trips (number) and effort (hours) for the South Atlantic Red Snapper closed season using the species list defined in Table 6.

Year	Season	Logbook Trips	Logbook Effort
2010	Closed	4,668	104,818
2011	Closed	4,708	101,886
2012	Closed	4,173	85,600
2013	Closed	3,728	80,021
2014	Closed	4,128	78,862
2015	Closed	4,616	91,908
2016	Closed	4,690	86,664
2017	Closed	4,133	75,322
2018	Closed	2,688	49,464
2019	Closed	3,302	62,556
2020	Closed	2,823	59,466
2021	Closed	2,394	50,645
2022	Closed	2,441	52,688
2023	Closed	2,486	49,888

Table 8. Estimated observer mean CPUE in weight and number by management regime and catch level strata for expansion estimates of vertical line South Atlantic Red Snapper catch and discards for the open season.

					Observer CPUE		
Management Regime	Season	Strata Type	Strata Level	Logbook CPUE	Kept	Discard (Weight)	Discard (Number)
Pre-closure 2007-2009	Open	Effort	L	2.744	3.102	1.216	0.314
Pre-closure 2007-2009	Open	Effort	H	1.176	0.729	0.586	0.200
Closure 2010-2024	Open	All	A	5.838	6.310	0.690	0.141

Table 9. Estimated observer mean CPUE in weight and number by management regime of vertical line South Atlantic Red Snapper discards for the closed season.

Management Regime	Season	Number of Observer Trips (n)	Observer Discard CPUE (Weight)	Observer Discard CPUE (Number)
Closure 2010-2017	Closed	58	1.742	0.268
Closure 2018-2023	Closed	97	2.244	0.352

Table 10. Time-series of CPUE expansion estimates for South Atlantic Red Snapper vertical line discards in weight (lbs.) and number (with associated standard errors).

Year	Season	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
1993	Open	62,528	21,893	17,252	5,204
1994	Open	67,202	23,391	18,580	5,571
1995	Open	65,648	23,454	17,988	5,543
1996	Open	50,717	18,114	13,898	4,281
1997	Open	41,864	14,397	11,625	3,443
1998	Open	34,194	12,182	9,378	2,881
1999	Open	35,555	12,869	9,700	3,032
2000	Open	37,992	13,845	10,341	3,257
2001	Open	63,468	21,517	17,717	5,175
2002	Open	69,714	23,515	19,498	5,668
2003	Open	50,178	16,399	14,213	4,018
2004	Open	54,764	18,803	15,216	4,500
2005	Open	46,427	16,559	12,728	3,915
2006	Open	28,840	9,730	8,065	2,345
2007	Open	53,386	22,918	14,950	5,763
2008	Open	64,579	27,723	17,676	6,814
2009	Open	65,287	28,027	17,833	6,875
2010	Open	225	61	46	10
2010	Closed	182,631	26,165	28,105	4,611
2011	Closed	177,523	25,433	27,319	4,482
2012	Open	1,202	325	245	56
2012	Closed	149,146	21,368	22,952	3,765
2013	Open	5,027	1,358	1,024	234
2013	Closed	139,426	19,975	21,456	3,520
2014	Open	9,933	2,682	2,023	462
2014	Closed	137,406	19,686	21,145	3,469
2015	Closed	160,137	22,943	24,643	4,043
2016	Closed	151,001	21,634	23,237	3,812
2017	Open	5,795	1,565	1,180	269
2017	Closed	131,238	18,802	20,196	3,313
2018	Open	14,516	3,920	2,956	675
2018	Closed	111,000	14,199	17,420	2,261
2019	Open	10,068	2,719	2,050	468
2019	Closed	140,380	17,957	22,031	2,860

Year	Season	Estimated Discards in Weight	SE of Estimated Discards in Weight	Estimated Discards in Number	SE of Estimated Discards in Number
2020	Open	11,046	2,983	2,249	513
2020	Closed	133,446	17,070	20,943	2,719
2021	Open	10,309	2,784	2,099	479
2021	Closed	113,652	14,538	17,836	2,315
2022	Open	8,981	2,425	1,829	417
2022	Closed	118,237	15,124	18,556	2,409
2023	Open	7,746	2,092	1,577	360
2023	Closed	111,952	14,320	17,570	2,281

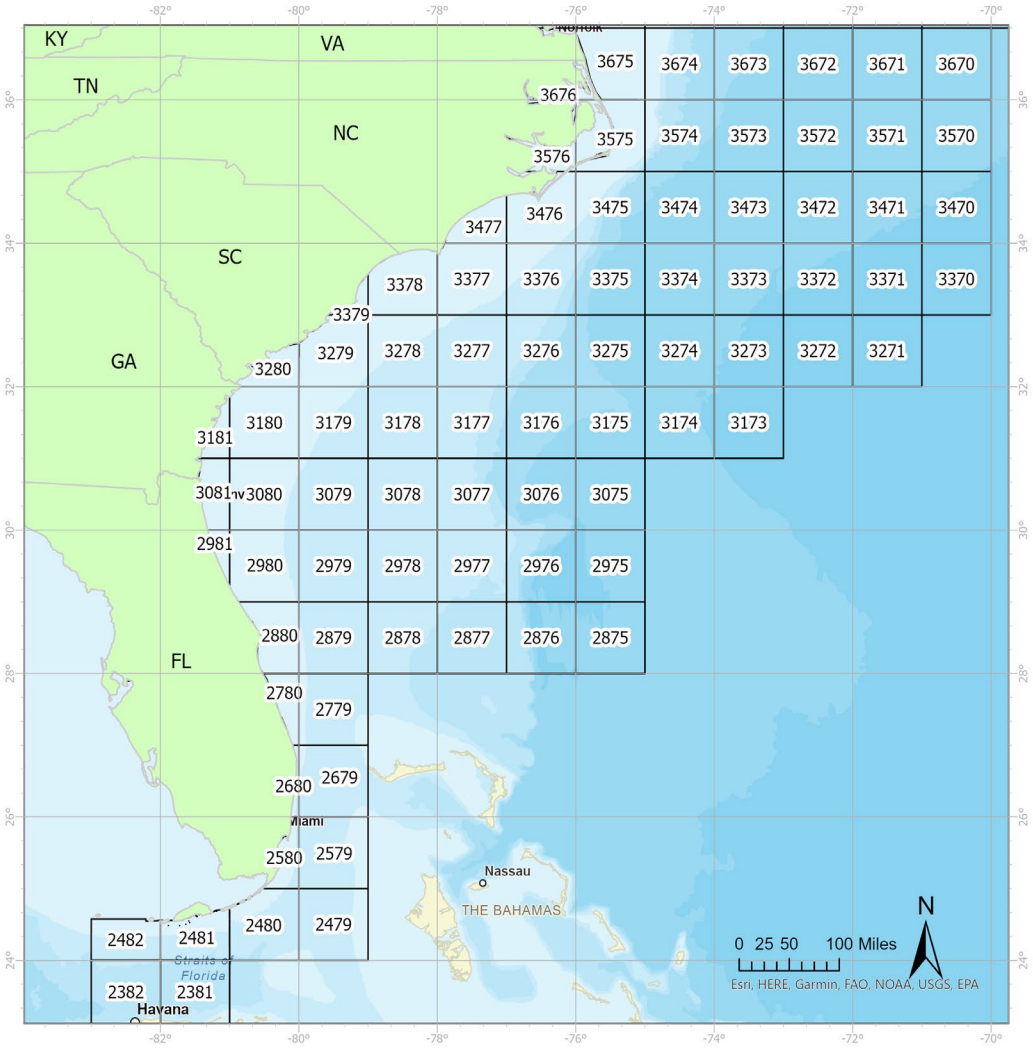


Figure 1. Map of South Atlantic fishing areas.

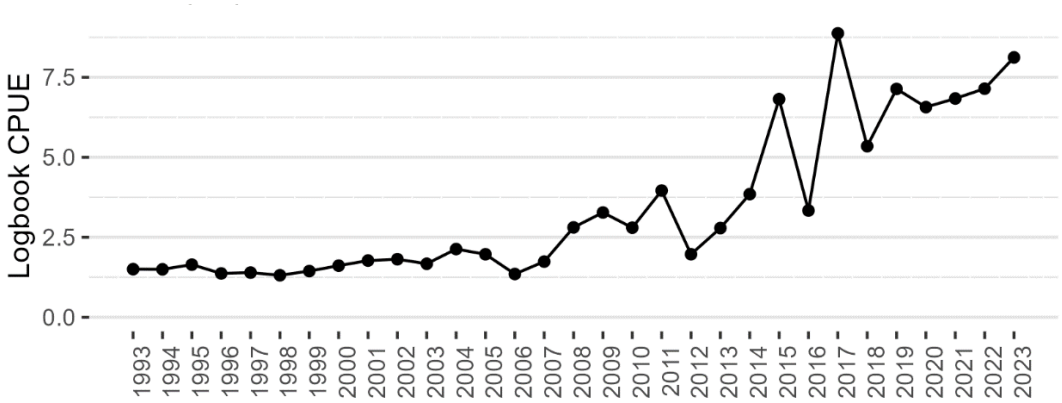


Figure 2. CPUE (catch in whole pounds per hour) time-series for logbook data from 1993 - 2023 for vertical line trips landing South Atlantic Red Snapper. The observer time period is from 2007 - 2023.

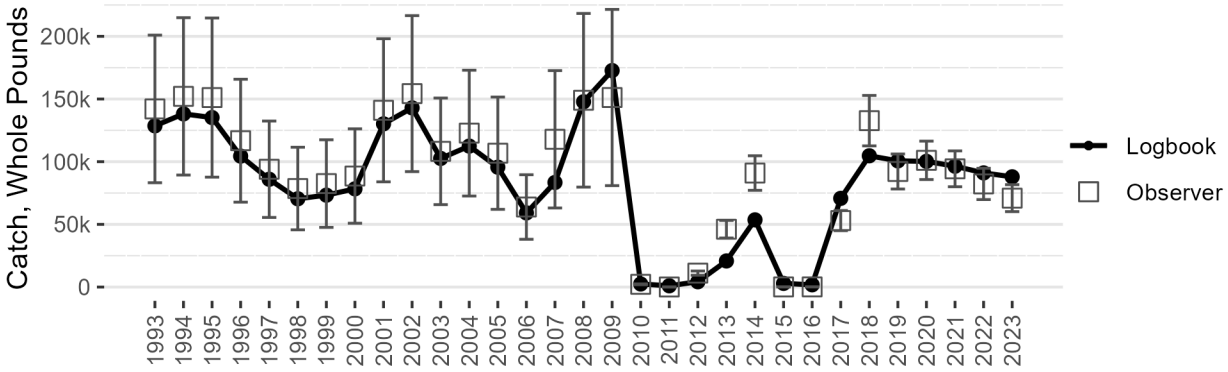


Figure 3. Comparison of vertical line reported annual logbook landings of South Atlantic Red Snapper (solid black line) with CPUE expansion estimates from observer data (open squares). Error bars (SE) are shown for observer estimates.

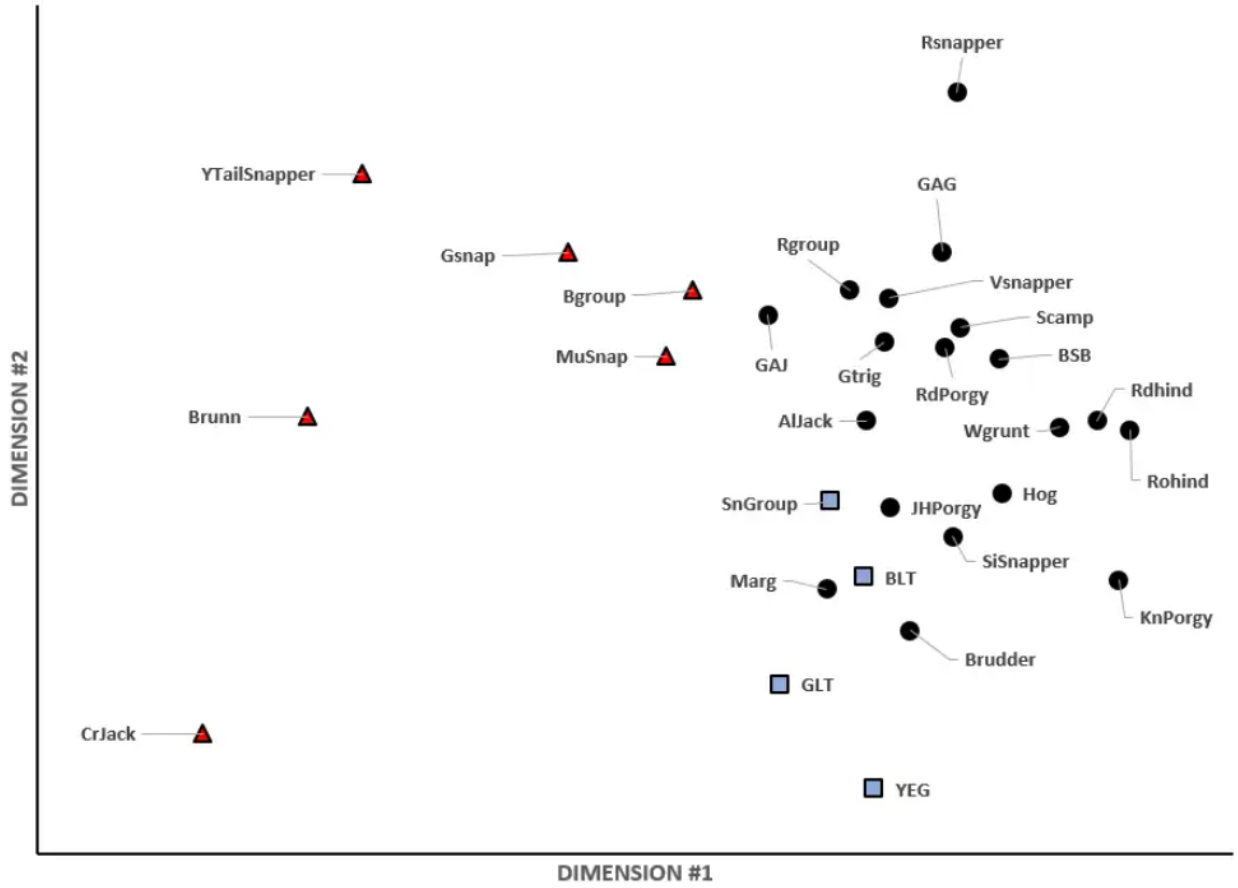
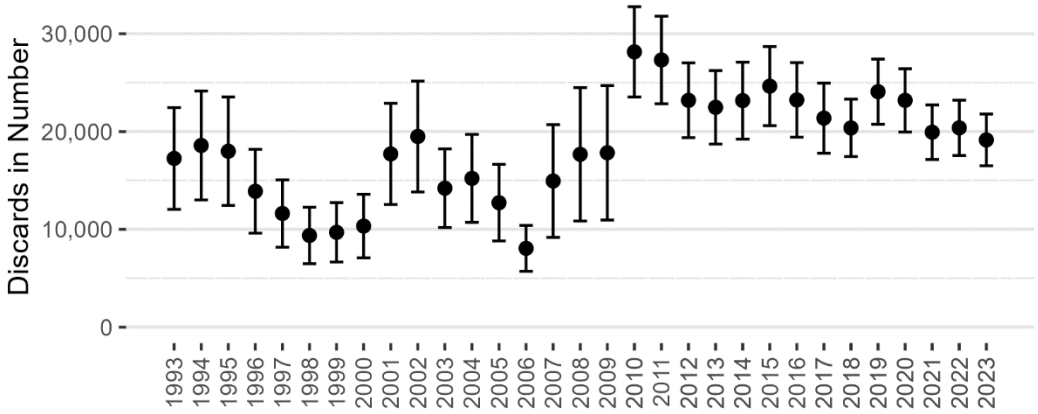


Figure 4. Ordination plot from NMDS analysis on commercial coastal logbook dataset (2010-2023) for the first two dimensions with three groups identified from the cluster analysis. Black circles represent the Northern Assemblage, red triangles represent the Southern Assemblage, and blue squares represent the Deepwater Assemblage.

(A) Discards in Number



(B) Discards in Weight, Percentage of Total Catch

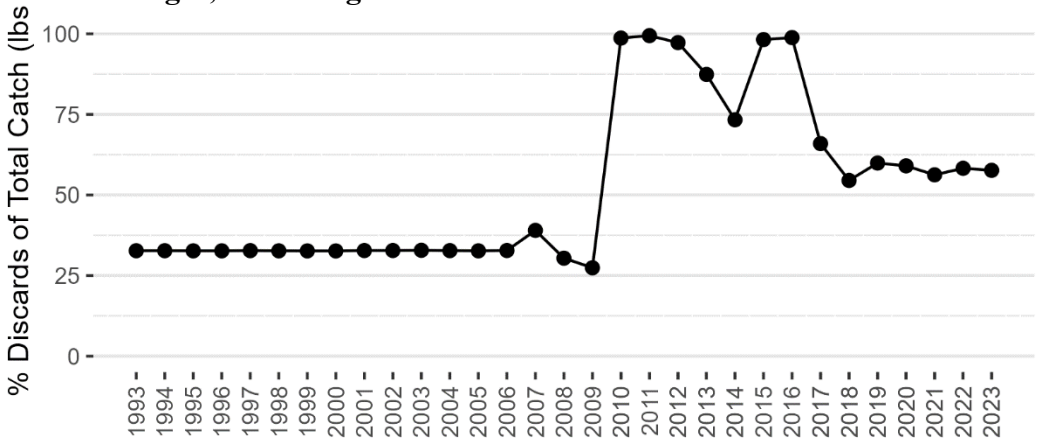


Figure 5. Observer CPUE expansion estimates of South Atlantic Red Snapper commercial vertical line annual discards (+/-SE) in (A) number and (B) weight expressed as percentage of total catch (kept + discards) for 1993 - 2023.

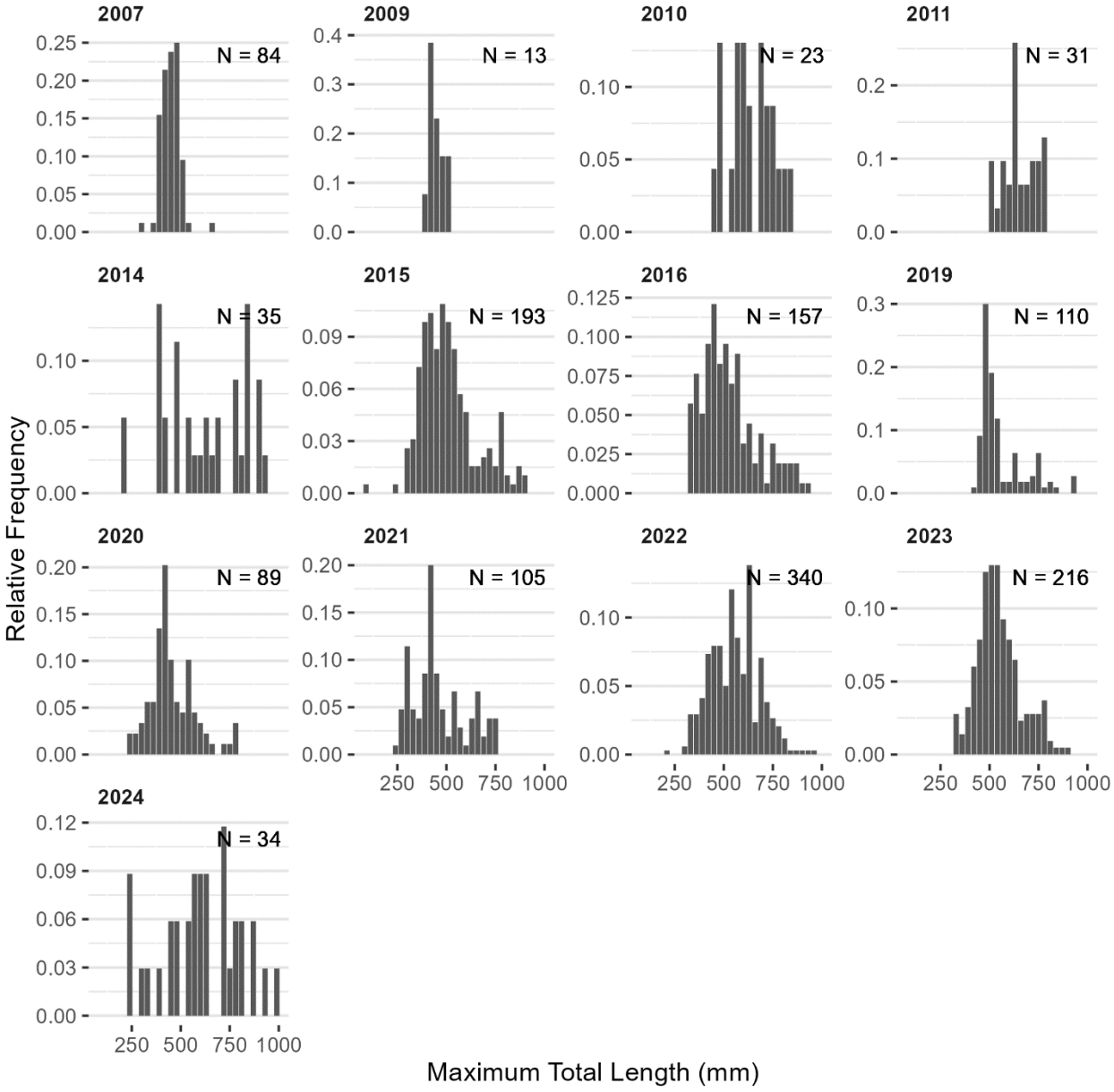


Figure 6. Commercial nominal discard length compositions for South Atlantic Red Snapper. N represents the number of discarded fish observed.

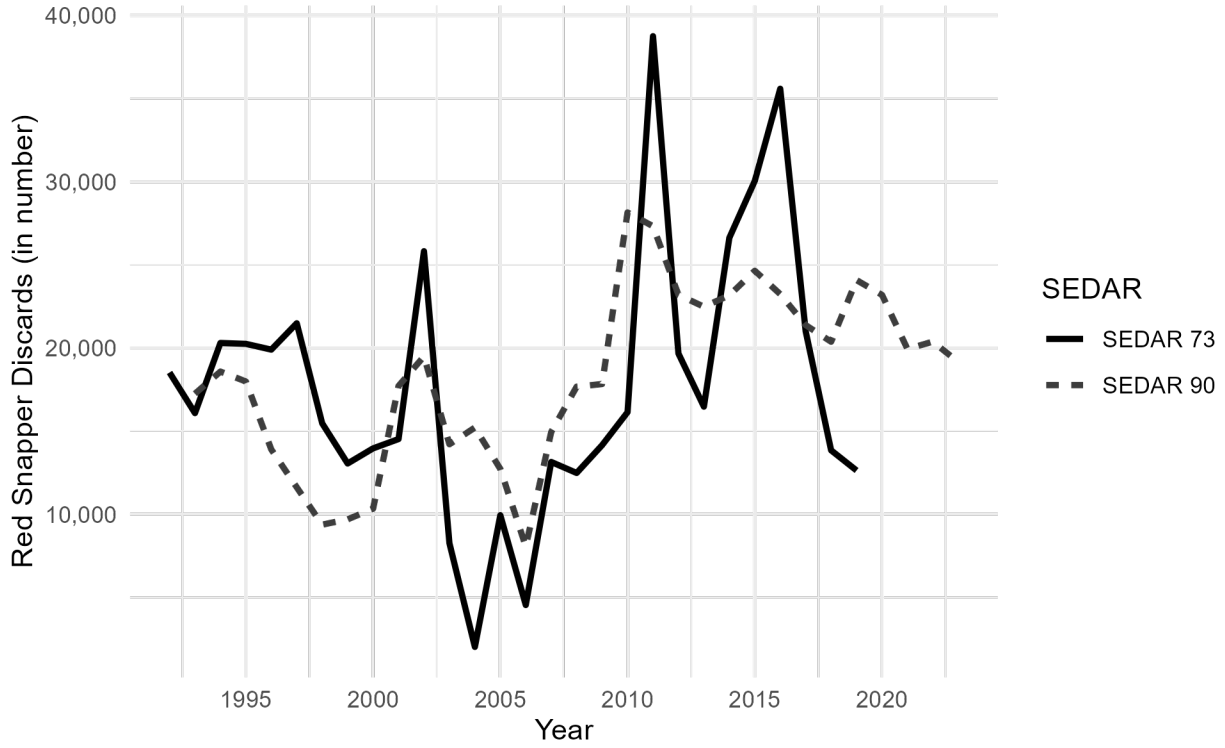


Figure 7. Commercial vertical line discard estimates of Red Snapper for SEDAR 90 compared to SEDAR 73.