# SEDAR 74 - DW12: SEFSC Computation of Uncertainty for General Recreational Landings-in-Weight Estimates, with Application to SEDAR 74 Gulf of Mexico Red Snapper

Matthew Nuttall and Kyle Dettloff

SEDAR82-RD53

Received: 9/20/2022

# SEFSC Computation of Uncertainty for General Recreational Landings-in-Weight Estimates, with Application to SEDAR 74 Gulf of Mexico Red Snapper

Matthew Nuttall and Kyle Dettloff

SEDAR74-DW-12

15 April 2022

Please cite this document as:

Nuttall, Matthew A. and Kyle Dettloff. 2022. SEFSC Computation of Uncertainty for General Recreational Landings-in-Weight Estimates, with Application to SEDAR 74 Gulf of Mexico Red Snapper. SEDAR74-DW-12. SEDAR, North Charleston, SC. 12 pp.

SEDAR 74-DW-12

# SEFSC Computation of Uncertainty for General Recreational Landings-in-Weight Estimates, with Application to SEDAR 74 Gulf of Mexico Red Snapper

**NOAA Fisheries**
**Southeast Fisheries Science Center**
**Sustainable Fisheries Division**
**75 Virginia Beach Drive**
**Miami FL 33149**

Matthew A. Nuttall and Kyle Dettloff

04-15-2022

---

## Introduction

The Southeast Fisheries Science Center (SEFSC) routinely provides stock assessment analysts with estimates of recreational catch and associated measures of uncertainty. Such provision has traditionally focused on estimates of catch-in-number because numbers are the native units of recreational monitoring surveys and the traditional inputs into stock assessment models for the southeast region (SFD 2021a). However, additional inputs for the relative size of landed fish may also be needed to properly constrain assessment model predictions of landings-in-weight, as required by fishery managers to set annual catch limits (SFD 2021b). This working paper introduces two possible approaches by which uncertainty may be represented for landings-in-weight estimates in SEDAR stock assessments.

The SEFSC estimates landings-in-weight ($\widehat{LBS}$) as the product of landings-in-number estimates ($\widehat{AB1}$) and average body weight ($\overline{WGT}$):

Equation (1)

$$\widehat{LBS}_{srysmwa} = \widehat{AB1}_{srysmwa} * \overline{WGT}_{srysmwa}$$

which are specific to species, region, year, state (or sub-state domain), mode, wave, and area fished ($srysmwa$). Landings-in-number estimates ($\widehat{AB1}$) are provided by each of the general recreational surveys operating throughout the southeast region:

- Marine Recreational Information Program (MRIP; Matter and Nuttall 2020)
- Texas Marine Sport-Harvest Monitoring Program (TPWD; Nuttall and Matter 2020)
- Louisiana Creel Survey (LACreel; LDWF 2017, 2020)

For average weight estimates ($\overline{WGT}$), the SEFSC calculates an average weight by strata from the raw size data collected by these three surveys using the same $srysmwa$ hierarchy (Matter and Rios 2013). The minimum number of weights used at each level of substitution is 15 fish, except for the final species level where the minimum is 1 fish (Dettloff and Matter 2019). As observed, (average) fish weights are estimated in pounds whole weight and are only available for landed fish; the size of discarded fish is unknown from these surveys. Fish weights for the TPWD survey are imputed from observed (total) length data and length-weight conversion factors derived from TPWD samples (Nuttall and Matter 2020).

Uncertainty estimates for landings-in-number ($\widehat{CV}(\widehat{AB1})$) are calculated from raw observations of catch at the intercept level, the method of which is described in Dettloff et al. (2020) and Nuttall et al. (2020). This estimation is based on standard survey methodology and accounts for the design of these regional surveys (i.e., its stratification). Conversely, uncertainty estimates for average weight ($\widehat{CV}(\overline{WGT})$) are more complicated in that SEFSC average weights are not always estimated at the same stratification as the associated catch-in-number estimates. SEFSC average weight estimation often requires strata to be collapsed to meet the minimum (15 fish) sample size threshold, resulting in individual size records being 'shared' across multiple survey strata and the associated average weight estimates not being independent across the strata to which they are applied (as in Equation 1). This non-independence of $\overline{WGT}$ complicates the statistical estimation of $\widehat{CV}(\overline{WGT})$ using standard survey methods. This working paper presents two approaches by which $\widehat{CV}(\overline{WGT})$ and, as a result, $\widehat{CV}(\widehat{LBS})$ may be represented in SEDAR stock assessments.

## Methods

### *Approach (1)*

The first approach is an extension of that used to estimate uncertainties for catch-in-numbers. As described in Nuttall et al. (2020), the variance in MRIP landings-in-numbers ($\hat{V}(\widehat{AB1_g})$):

Equation (2)

$$\hat{V}(\widehat{AB1_g}) = \sum_{h=1}^{n_g} \frac{n_h}{n_h - 1} \sum_{i=1}^{n_h} (y_{hi} - \overline{y_h})^2$$

is calculated from all $n$ observations of MRIP landings-in-number ($y_{hi}$), at the PSU-level (primary sampling unit), across the $h$ ($srysmwa$) survey strata in each $g$ data aggregation (e.g., by year and mode). This variance is then converted to a coefficient of variation to represent the uncertainty in landings-in-number estimates ($\widehat{CV}(\widehat{AB1_g})$).

Approach (1) is a modification to this estimation. Following Equation (1), the $y_{hi}$ terms in Equation (2) are replaced by the product of the raw landings-in-number observations and associated SEFSC average weight estimates ($\overline{WGT_g}$). The resultant variance is then converted to a $CV$ to represent the uncertainty in landings-in-weight ($\widehat{CV}(\widehat{LBS_g})$). This approach treats SEFSC average weights as constants, with no uncertainty considered at the observation level.

### *Approach (2)*

Alternatively, the second approach uses the variability in raw size data as a proxy for the uncertainty in SEFSC average weight estimates. Specifically, all observations of fish weight are averaged at the trip level, providing estimates of (landed) fish weight that account for any correlation in fish sizes sampled from the same intercept. The mean and standard error of these trip-level weight summaries are then calculated for the same strata used in SEFSC weight estimation ($srysmwa$), combined to produce estimates at the $g$ aggregation level (e.g., year and mode), and converted to coefficients of variation. These $CV$s are assumed representative of $\widehat{CV}(\overline{WGT_g})$.

To estimate uncertainty for landings-in-weight, these $CV$s are converted back into variances ($\hat{V}(\overline{WGT_g})$) using the associated SEFSC average weight estimates ($\overline{WGT_g}$), which were estimated from the approach described in the introduction and differ from the (trip-level) mean weights calculated above. Assuming survey estimates of landings-in-number and SEFSC average weights are independent for each $g$ aggregation, the variance product law is then applied to calculate the variance of landings-in-weight (Goodman 1960):

Equation (3)

$$\hat{V}(\widehat{LBS_g}) = (\widehat{AB1_g}^2 * \hat{V}(\overline{WGT_g})) + (\overline{WGT_g}^2 * \hat{V}(\widehat{AB1_g})) - (\hat{V}(\overline{WGT_g}) * \hat{V}(\widehat{AB1_g}))$$

which is converted to a $CV$ and provided as a measure of uncertainty for landings-in-weight ($\widehat{CV}(\widehat{LBS_g})$).

---

## Results - Gulf of Mexico Red Snapper

### *Uncertainty of Landings-in-Number*

For reference, the landings-in-number estimates and associated uncertainties for Gulf of Mexico Red Snapper are provided in Table 1. These are the same estimates provided in Tables 3 and 5 of SEDAR 74-DW-01.

### *Uncertainty in Landings-in-Weight: Approach (1)*

This approach treats SEFSC average weight estimates as constants at the observation level and results in uncertainty estimates for landings-in-weight similar to those for landings-in-number (Table 1 vs. Table 2). Because SEFSC average weights are estimated at the strata level (e.g., $srysmwa$) but applied at the observation level, the same average weights can be applied to multiple catch records. In such cases, the $\overline{WGT_g}$ estimates are largely acting as scaling factors on each landings-in-number observation and do little in changing the unitless $\widehat{CV}(\widehat{LBS_g})$ estimates from the $\widehat{CV}(\widehat{AB1_g})$ estimates that would have been calculated for landings-in-number (Equation 2). The small differences that do exist between the two sets of $CV$ estimates are driven by differences in SEFSC average weights across strata.

### *Uncertainty in Landings-in-Weight: Approach (2)*

To relax the assumption of no uncertainty in SEFSC average weights (as in Approach 1), the second approach assumes the variability in raw size data (Table 3) is representative of the uncertainty in SEFSC average weight estimates. These uncertainties are calculated as a standard error ($\sigma/\sqrt{n}$) and, therefore, their precision is a direct reflection of the number of fishing trips ($n$) intercepted in a given strata. The use of a proxy for $\widehat{CV}(\overline{WGT_g})$ tends to result in larger uncertainty estimates for landings-in-weight than landings-in-number (Table 1 vs. Table 4), but the immense sampling effort of general recreational surveys operating throughout the southeast region minimizes this difference for well-sampled species (e.g., Gulf of Mexico Red Snapper).

---

## Discussion - Approach (1) vs. Approach (2)

The true estimates for $\widehat{CV}(\widehat{LBS_g})$ are believed to be an intermediate between those provided by Approaches 1 and 2 (Figure 1). Approach (1) treats $\overline{WGT_g}$ as a constant, resulting in $\widehat{LBS_g}$ estimates that are likely too precise and an underestimate of the true uncertainty in landings-in-weight. Approach (2) applies the variability in raw size data as a proxy for $\widehat{CV}(\overline{WGT_g})$, but does not account for size records being 'shared' across multiple strata in the SEFSC average weight estimation method. Approach (2) is therefore believed to produce $\widehat{CV}(\widehat{LBS_g})$ that are an overestimate. It is unclear which approach provides $\widehat{CV}(\widehat{LBS_g})$ estimates that are closer to the true sampling uncertainty in landings-in-weight, but taken together, they are believed to provide an upper and lower bound of this variability.

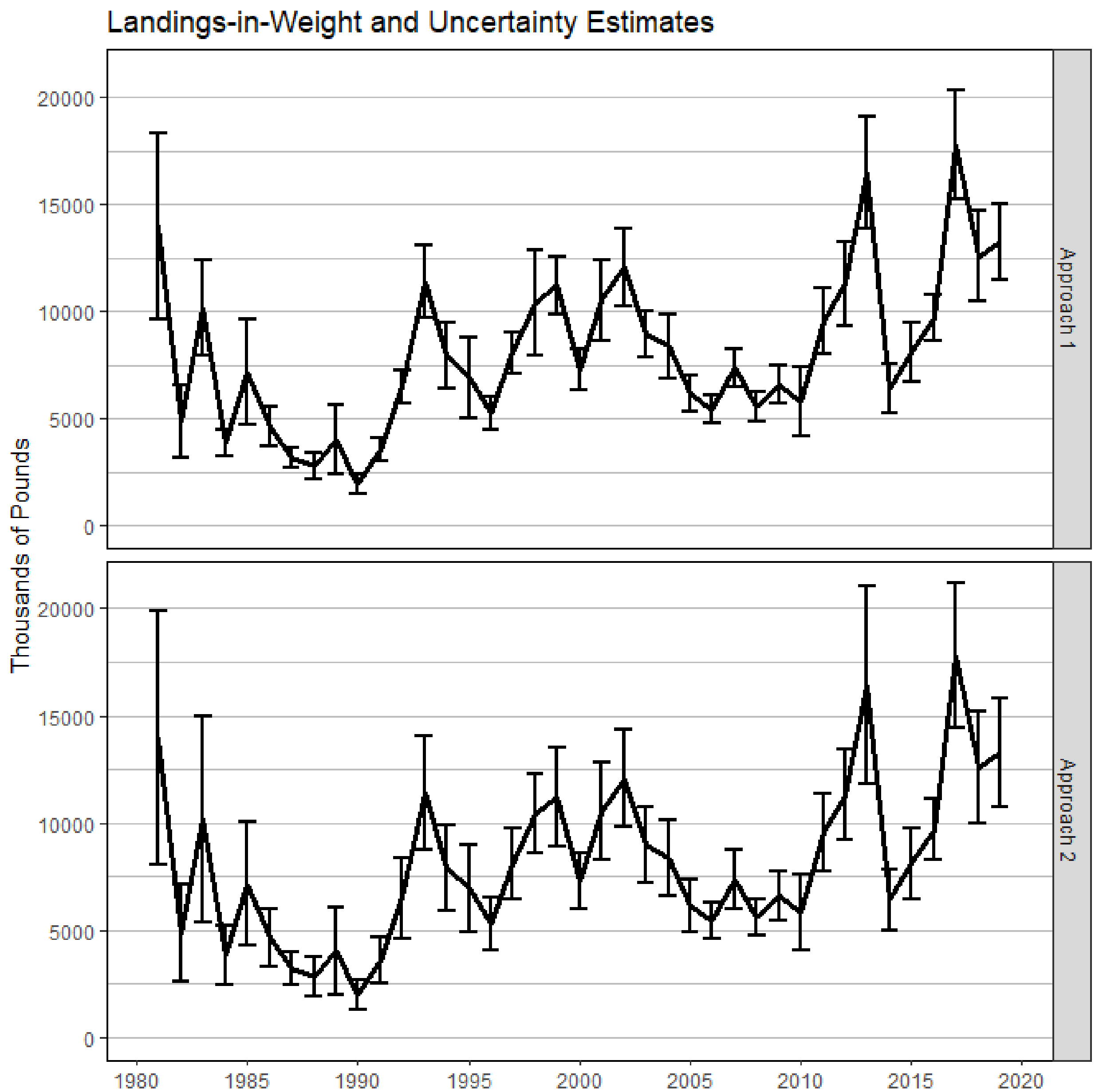


***Figure 1****. Comparison of the uncertainty estimates (standard errors) for annual landings-in-weight between Approaches (1) and (2). Estimates are combined across modes and provided in pounds whole weight.*

***Table 1**. Annual landings of Gulf of Mexico Red Snapper in numbers of fish (AB1) with associated coefficients of variation (CV) by year and mode (MRIP only).*

| | CBT | | HBT | | PRIV | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| YEAR | AB1 | CV | AB1 | CV | AB1 | CV | AB1 | CV |
| 1981 | 1,642,314 | 0.70 | 909,276 | 0.79 | 3,888,578 | 0.44 | 6,440,167 | 0.34 |
| 1982 | 682,022 | 0.46 | 273,441 | 0.40 | 1,395,657 | 0.45 | 2,351,121 | 0.32 |
| 1983 | 1,208,869 | 0.23 | 534,722 | 0.28 | 4,220,233 | 0.32 | 5,963,825 | 0.23 |
| 1984 | 620,763 | 0.29 | 183,963 | 0.29 | 696,591 | 0.35 | 1,501,317 | 0.18 |
| 1985 | 856,137 | 0.44 | 209,233 | 0.32 | 1,021,238 | 0.38 | 2,086,608 | 0.27 |
| 1986 | 641,023 | 0.18 | | | 781,785 | 0.31 | 1,422,808 | 0.18 |
| 1987 | 514,903 | 0.22 | | | 709,007 | 0.23 | 1,223,910 | 0.15 |
| 1988 | 378,460 | 0.31 | | | 644,932 | 0.32 | 1,023,391 | 0.23 |
| 1989 | 277,524 | 0.26 | | | 1,010,072 | 0.46 | 1,287,596 | 0.37 |
| 1990 | 171,954 | 0.29 | | | 515,021 | 0.31 | 686,975 | 0.24 |
| 1991 | 304,382 | 0.17 | | | 853,842 | 0.23 | 1,158,224 | 0.16 |
| 1992 | 477,807 | 0.15 | | | 1,677,844 | 0.17 | 2,155,651 | 0.12 |
| 1993 | 910,743 | 0.31 | | | 2,048,807 | 0.18 | 2,959,550 | 0.15 |
| 1994 | 420,330 | 0.19 | | | 1,370,790 | 0.22 | 1,791,120 | 0.16 |
| 1995 | 363,081 | 0.24 | | | 1,200,546 | 0.29 | 1,563,627 | 0.22 |
| 1996 | 473,620 | 0.28 | | | 751,622 | 0.18 | 1,225,242 | 0.15 |
| 1997 | 606,859 | 0.14 | | | 1,065,734 | 0.18 | 1,672,593 | 0.12 |
| 1998 | 974,200 | 0.10 | | | 980,106 | 0.25 | 1,954,307 | 0.13 |
| 1999 | 680,961 | 0.10 | | | 1,479,940 | 0.21 | 2,160,901 | 0.14 |
| 2000 | 388,972 | 0.08 | | | 1,038,840 | 0.19 | 1,427,812 | 0.13 |
| 2001 | 403,657 | 0.09 | | | 1,474,435 | 0.21 | 1,878,092 | 0.17 |
| 2002 | 595,100 | 0.09 | | | 1,905,992 | 0.20 | 2,501,091 | 0.15 |
| 2003 | 578,111 | 0.08 | | | 1,321,517 | 0.19 | 1,899,628 | 0.13 |
| 2004 | 604,641 | 0.09 | | | 1,658,750 | 0.27 | 2,263,391 | 0.19 |
| 2005 | 451,598 | 0.10 | | | 1,034,697 | 0.22 | 1,486,295 | 0.15 |
| 2006 | 484,203 | 0.10 | | | 1,128,336 | 0.18 | 1,612,540 | 0.12 |
| 2007 | 529,303 | 0.10 | | | 1,717,979 | 0.20 | 2,247,282 | 0.15 |
| 2008 | 287,711 | 0.11 | | | 985,101 | 0.16 | 1,272,812 | 0.12 |
| 2009 | 230,837 | 0.15 | | | 1,204,512 | 0.19 | 1,435,349 | 0.15 |
| 2010 | 73,227 | 0.17 | | | 1,048,012 | 0.31 | 1,121,239 | 0.28 |
| 2011 | 157,768 | 0.19 | | | 1,318,094 | 0.19 | 1,475,862 | 0.16 |
| 2012 | 175,817 | 0.16 | | | 1,305,582 | 0.20 | 1,481,398 | 0.16 |
| 2013 | 180,951 | 0.33 | | | 2,193,730 | 0.30 | 2,374,681 | 0.26 |
| 2014 | 39,171 | 0.25 | | | 898,238 | 0.21 | 937,408 | 0.19 |
| 2015 | 212,984 | 0.22 | | | 1,025,222 | 0.23 | 1,238,206 | 0.18 |
| 2016 | 226,081 | 0.21 | | | 1,308,242 | 0.14 | 1,534,323 | 0.11 |
| 2017 | 258,798 | 0.24 | | | 2,645,522 | 0.19 | 2,904,320 | 0.16 |
| 2018 | 252,592 | 0.21 | | | 1,852,355 | 0.23 | 2,104,947 | 0.19 |
| 2019 | 300,071 | 0.26 | | | 2,053,198 | 0.19 | 2,353,269 | 0.16 |

***Table 2***. *Annual landings of Gulf of Mexico Red Snapper in pounds whole weight (LBS) with associated coefficients of variation (CV) by year and mode (MRIP only). SEFSC average weight estimates are treated as data in this approach (1).*

| | CBT | | HBT | | PRIV | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| YEAR | LBS | CV | LBS | CV | LBS | CV | LBS | CV |
| 1981 | 3,233,825 | 0.36 | 2,177,130 | 0.41 | 8,560,852 | 0.45 | 13,971,807 | 0.31 |
| 1982 | 1,171,467 | 0.42 | 337,133 | 0.31 | 3,340,760 | 0.47 | 4,849,359 | 0.35 |
| 1983 | 2,192,914 | 0.16 | 1,076,622 | 0.25 | 6,915,645 | 0.31 | 10,185,181 | 0.22 |
| 1984 | 2,186,141 | 0.16 | 448,787 | 0.30 | 1,226,067 | 0.34 | 3,860,995 | 0.15 |
| 1985 | 4,307,873 | 0.51 | 448,496 | 0.29 | 2,411,342 | 0.39 | 7,167,711 | 0.34 |
| 1986 | 2,244,621 | 0.17 | | | 2,406,326 | 0.35 | 4,650,948 | 0.20 |
| 1987 | 1,513,731 | 0.21 | | | 1,683,970 | 0.20 | 3,197,701 | 0.15 |
| 1988 | 1,159,253 | 0.29 | | | 1,660,135 | 0.32 | 2,819,388 | 0.22 |
| 1989 | 758,298 | 0.22 | | | 3,272,375 | 0.48 | 4,030,673 | 0.39 |
| 1990 | 841,844 | 0.42 | | | 1,127,090 | 0.27 | 1,968,934 | 0.24 |
| 1991 | 998,043 | 0.16 | | | 2,592,697 | 0.20 | 3,590,740 | 0.15 |
| 1992 | 1,514,053 | 0.12 | | | 4,966,538 | 0.15 | 6,480,591 | 0.12 |
| 1993 | 3,107,254 | 0.28 | | | 8,302,495 | 0.17 | 11,409,749 | 0.15 |
| 1994 | 1,739,851 | 0.16 | | | 6,190,859 | 0.24 | 7,930,709 | 0.19 |
| 1995 | 1,293,865 | 0.24 | | | 5,644,003 | 0.33 | 6,937,868 | 0.27 |
| 1996 | 2,160,608 | 0.25 | | | 3,104,012 | 0.16 | 5,264,620 | 0.14 |
| 1997 | 3,077,539 | 0.12 | | | 5,007,466 | 0.18 | 8,085,004 | 0.12 |
| 1998 | 4,130,626 | 0.08 | | | 6,286,235 | 0.39 | 10,416,860 | 0.24 |
| 1999 | 3,173,963 | 0.09 | | | 8,042,325 | 0.16 | 11,216,288 | 0.12 |
| 2000 | 1,836,879 | 0.06 | | | 5,437,337 | 0.17 | 7,274,216 | 0.13 |
| 2001 | 1,878,290 | 0.07 | | | 8,656,747 | 0.22 | 10,535,037 | 0.18 |
| 2002 | 2,799,931 | 0.06 | | | 9,266,752 | 0.19 | 12,066,682 | 0.15 |
| 2003 | 2,816,828 | 0.06 | | | 6,144,119 | 0.17 | 8,960,947 | 0.12 |
| 2004 | 2,137,060 | 0.06 | | | 6,257,514 | 0.24 | 8,394,573 | 0.18 |
| 2005 | 1,648,121 | 0.08 | | | 4,510,090 | 0.18 | 6,158,211 | 0.14 |
| 2006 | 1,608,221 | 0.07 | | | 3,826,373 | 0.16 | 5,434,593 | 0.12 |
| 2007 | 1,702,967 | 0.07 | | | 5,668,034 | 0.16 | 7,371,001 | 0.12 |
| 2008 | 1,159,543 | 0.08 | | | 4,428,359 | 0.16 | 5,587,902 | 0.13 |
| 2009 | 1,283,871 | 0.11 | | | 5,305,857 | 0.16 | 6,589,728 | 0.13 |
| 2010 | 402,356 | 0.11 | | | 5,413,449 | 0.30 | 5,815,805 | 0.28 |
| 2011 | 998,017 | 0.13 | | | 8,555,363 | 0.18 | 9,553,380 | 0.16 |
| 2012 | 1,265,231 | 0.13 | | | 10,026,717 | 0.19 | 11,291,948 | 0.17 |
| 2013 | 1,298,143 | 0.19 | | | 15,157,942 | 0.17 | 16,456,085 | 0.16 |
| 2014 | 254,177 | 0.23 | | | 6,154,335 | 0.19 | 6,408,512 | 0.18 |
| 2015 | 1,379,557 | 0.18 | | | 6,725,601 | 0.21 | 8,105,158 | 0.17 |
| 2016 | 1,712,017 | 0.17 | | | 7,987,528 | 0.13 | 9,699,545 | 0.11 |
| 2017 | 1,589,921 | 0.18 | | | 16,208,936 | 0.15 | 17,798,857 | 0.14 |
| 2018 | 1,584,356 | 0.17 | | | 10,999,343 | 0.19 | 12,583,699 | 0.17 |
| 2019 | 1,775,554 | 0.19 | | | 11,480,040 | 0.15 | 13,255,594 | 0.13 |

***Table 3****. Average weight of landed Gulf of Mexico Red Snapper (WGT) with associated coefficients of variation (CV) by year and mode, as calculated from the raw size data. Note that the average weights provided in this table differ from SEFSC average weight estimates (Equation 1), which are estimated at the finest strata meeting a minimum (15 fish) sample size threshold.*

| | CBT | | HBT | | PRIV | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| YEAR | WGT | CV | WGT | CV | WGT | CV | WGT | CV |
| 1981 | 3.30 | 0.27 | 2.67 | 0.28 | 2.01 | 0.23 | 2.65 | 0.27 |
| 1982 | 2.04 | 0.43 | 2.00 | 0.04 | 2.48 | 0.45 | 2.18 | 0.36 |
| 1983 | 2.00 | 0.25 | 2.37 | 0.45 | 1.45 | 0.55 | 2.04 | 0.42 |
| 1984 | 3.55 | 0.16 | 2.72 | 0.27 | 1.84 | 0.60 | 2.70 | 0.31 |
| 1985 | 2.82 | 0.33 | 2.36 | 0.22 | 1.62 | 0.30 | 2.13 | 0.30 |
| 1986 | 3.36 | 0.20 | | | 1.98 | 0.34 | 2.96 | 0.22 |
| 1987 | 3.16 | 0.16 | | | 1.97 | 0.23 | 2.55 | 0.19 |
| 1988 | 2.87 | 0.15 | | | 1.73 | 0.32 | 2.06 | 0.25 |
| 1989 | 3.54 | 0.36 | | | 2.26 | 0.33 | 2.88 | 0.36 |
| 1990 | 3.65 | 0.27 | | | 2.11 | 0.28 | 2.66 | 0.28 |
| 1991 | 3.37 | 0.23 | | | 2.30 | 0.29 | 2.87 | 0.25 |
| 1992 | 3.64 | 0.29 | | | 2.62 | 0.21 | 3.12 | 0.27 |
| 1993 | 3.59 | 0.17 | | | 3.08 | 0.19 | 3.30 | 0.18 |
| 1994 | 3.87 | 0.19 | | | 3.03 | 0.20 | 3.35 | 0.20 |
| 1995 | 3.71 | 0.21 | | | 3.35 | 0.20 | 3.43 | 0.20 |
| 1996 | 4.85 | 0.18 | | | 3.67 | 0.18 | 4.00 | 0.18 |
| 1997 | 5.45 | 0.17 | | | 3.94 | 0.16 | 4.60 | 0.17 |
| 1998 | 3.95 | 0.08 | | | 4.16 | 0.16 | 4.04 | 0.12 |
| 1999 | 4.86 | 0.09 | | | 5.41 | 0.22 | 5.06 | 0.15 |
| 2000 | 4.28 | 0.10 | | | 4.38 | 0.17 | 4.31 | 0.13 |
| 2001 | 4.25 | 0.09 | | | 4.44 | 0.18 | 4.32 | 0.13 |
| 2002 | 4.23 | 0.07 | | | 4.22 | 0.16 | 4.23 | 0.11 |
| 2003 | 4.17 | 0.14 | | | 4.24 | 0.16 | 4.20 | 0.15 |
| 2004 | 3.42 | 0.07 | | | 3.51 | 0.13 | 3.45 | 0.09 |
| 2005 | 3.36 | 0.08 | | | 3.85 | 0.18 | 3.52 | 0.13 |
| 2006 | 3.13 | 0.07 | | | 3.32 | 0.12 | 3.21 | 0.10 |
| 2007 | 3.17 | 0.07 | | | 3.56 | 0.14 | 3.33 | 0.11 |
| 2008 | 3.95 | 0.09 | | | 4.25 | 0.11 | 4.09 | 0.10 |
| 2009 | 5.39 | 0.09 | | | 5.00 | 0.10 | 5.15 | 0.09 |
| 2010 | 5.33 | 0.12 | | | 5.47 | 0.10 | 5.40 | 0.11 |
| 2011 | 6.13 | 0.10 | | | 5.71 | 0.10 | 5.86 | 0.10 |
| 2012 | 6.88 | 0.09 | | | 6.29 | 0.10 | 6.54 | 0.10 |
| 2013 | 7.24 | 0.13 | | | 6.49 | 0.10 | 6.64 | 0.11 |
| 2014 | 6.88 | 0.14 | | | 6.25 | 0.12 | 6.40 | 0.12 |
| 2015 | 6.94 | 0.10 | | | 5.96 | 0.10 | 6.33 | 0.10 |
| 2016 | 7.03 | 0.09 | | | 6.23 | 0.11 | 6.51 | 0.10 |
| 2017 | 6.71 | 0.10 | | | 6.03 | 0.10 | 6.22 | 0.10 |
| 2018 | 7.60 | 0.08 | | | 6.20 | 0.09 | 6.74 | 0.09 |
| 2019 | 6.80 | 0.11 | | | 5.82 | 0.11 | 6.12 | 0.11 |

***Table 4**. Annual landings of Gulf of Mexico Red Snapper in pounds whole weight (LBS) with associated coefficients of variation (CV) by year and mode (MRIP only). Variability in the raw size data is used as a proxy for uncertainty in SEFSC average weights in this approach (2).*

| | CBT | | HBT | | PRIV | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| YEAR | LBS | CV | LBS | CV | LBS | CV | LBS | CV |
| 1981 | 3,233,825 | 0.73 | 2,177,130 | 0.81 | 8,560,852 | 0.49 | 13,971,807 | 0.43 |
| 1982 | 1,171,467 | 0.60 | 337,133 | 0.40 | 3,340,760 | 0.61 | 4,849,359 | 0.47 |
| 1983 | 2,192,914 | 0.33 | 1,076,622 | 0.51 | 6,915,645 | 0.61 | 10,185,181 | 0.47 |
| 1984 | 2,186,141 | 0.33 | 448,787 | 0.39 | 1,226,067 | 0.66 | 3,860,995 | 0.36 |
| 1985 | 4,307,873 | 0.53 | 448,496 | 0.38 | 2,411,342 | 0.47 | 7,167,711 | 0.40 |
| 1986 | 2,244,621 | 0.26 | | | 2,406,326 | 0.45 | 4,650,948 | 0.29 |
| 1987 | 1,513,731 | 0.27 | | | 1,683,970 | 0.32 | 3,197,701 | 0.24 |
| 1988 | 1,159,253 | 0.34 | | | 1,660,135 | 0.44 | 2,819,388 | 0.33 |
| 1989 | 758,298 | 0.44 | | | 3,272,375 | 0.55 | 4,030,673 | 0.50 |
| 1990 | 841,844 | 0.39 | | | 1,127,090 | 0.41 | 1,968,934 | 0.36 |
| 1991 | 998,043 | 0.28 | | | 2,592,697 | 0.36 | 3,590,740 | 0.30 |
| 1992 | 1,514,053 | 0.32 | | | 4,966,538 | 0.27 | 6,480,591 | 0.29 |
| 1993 | 3,107,254 | 0.35 | | | 8,302,495 | 0.26 | 11,409,749 | 0.23 |
| 1994 | 1,739,851 | 0.27 | | | 6,190,859 | 0.29 | 7,930,709 | 0.25 |
| 1995 | 1,293,865 | 0.32 | | | 5,644,003 | 0.35 | 6,937,868 | 0.29 |
| 1996 | 2,160,608 | 0.33 | | | 3,104,012 | 0.25 | 5,264,620 | 0.23 |
| 1997 | 3,077,539 | 0.22 | | | 5,007,466 | 0.24 | 8,085,004 | 0.20 |
| 1998 | 4,130,626 | 0.13 | | | 6,286,235 | 0.29 | 10,416,860 | 0.18 |
| 1999 | 3,173,963 | 0.13 | | | 8,042,325 | 0.30 | 11,216,288 | 0.21 |
| 2000 | 1,836,879 | 0.13 | | | 5,437,337 | 0.25 | 7,274,216 | 0.18 |
| 2001 | 1,878,290 | 0.13 | | | 8,656,747 | 0.27 | 10,535,037 | 0.21 |
| 2002 | 2,799,931 | 0.12 | | | 9,266,752 | 0.25 | 12,066,682 | 0.19 |
| 2003 | 2,816,828 | 0.16 | | | 6,144,119 | 0.25 | 8,960,947 | 0.20 |
| 2004 | 2,137,060 | 0.11 | | | 6,257,514 | 0.30 | 8,394,573 | 0.21 |
| 2005 | 1,648,121 | 0.13 | | | 4,510,090 | 0.28 | 6,158,211 | 0.20 |
| 2006 | 1,608,221 | 0.12 | | | 3,826,373 | 0.22 | 5,434,593 | 0.16 |
| 2007 | 1,702,967 | 0.12 | | | 5,668,034 | 0.24 | 7,371,001 | 0.18 |
| 2008 | 1,159,543 | 0.14 | | | 4,428,359 | 0.19 | 5,587,902 | 0.15 |
| 2009 | 1,283,871 | 0.17 | | | 5,305,857 | 0.21 | 6,589,728 | 0.18 |
| 2010 | 402,356 | 0.21 | | | 5,413,449 | 0.32 | 5,815,805 | 0.30 |
| 2011 | 998,017 | 0.21 | | | 8,555,363 | 0.22 | 9,553,380 | 0.19 |
| 2012 | 1,265,231 | 0.18 | | | 10,026,717 | 0.22 | 11,291,948 | 0.19 |
| 2013 | 1,298,143 | 0.35 | | | 15,157,942 | 0.31 | 16,456,085 | 0.28 |
| 2014 | 254,177 | 0.28 | | | 6,154,335 | 0.24 | 6,408,512 | 0.22 |
| 2015 | 1,379,557 | 0.24 | | | 6,725,601 | 0.25 | 8,105,158 | 0.21 |
| 2016 | 1,712,017 | 0.23 | | | 7,987,528 | 0.18 | 9,699,545 | 0.15 |
| 2017 | 1,589,921 | 0.26 | | | 16,208,936 | 0.22 | 17,798,857 | 0.19 |
| 2018 | 1,584,356 | 0.22 | | | 10,999,343 | 0.25 | 12,583,699 | 0.21 |
| 2019 | 1,775,554 | 0.28 | | | 11,480,040 | 0.22 | 13,255,594 | 0.19 |

## References

Dettloff, K and V Matter. 2019. SEDAR 67-WP-06. Sample Size Sensitivity Analysis for calculating MRIP Weight Estimates. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Fisheries Statistics Division. Miami, FL.

Dettloff, K, VM Matter, and MA Nuttall. 2020. SEDAR 68-DW-10. SEFSC computation of variance estimates for custom data aggregations from the Marine Recreational Information Program. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Fisheries Statistics Division. Miami, FL.

Goodman, LA. 1960. On the Exact Variance of Products. Journal of the American Statistical Association 55(292): 708-713.

LDWF (Louisiana Department of Wildlife and Fisheries). December 11, 2017. Sampling Protocol for the LA Creel Survey: Interviewer Manual. LDWF Recreational Statistics Program. Baton Rouge, LA. Provided June 25, 2020.

LDWF. April 7, 2020. Saltwater Finfish Landing Statistics: LA Creel Survey. LDWF Recreational Statistics Program. Baton Rouge, LA. Provided June 25, 2020.

Matter, VM and A Rios. 2013. SEDAR 32-DW-02. MRFSS to MRIP Adjustment Ratios and Weight Estimation Procedures for South Atlantic and Gulf of Mexico Managed Species. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Fisheries Statistics Division. Miami, FL.

Matter, VM and MA Nuttall. 2020. SEDAR 68-DW-13. Marine Recreational Information Program Metadata for the Atlantic, Gulf of Mexico, and Caribbean regions. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Fisheries Statistics Division (FSD). Miami, FL. 16 pp.

Nuttall, MA and VM Matter. 2020. SEDAR 70-WP-03. Texas Parks and Wildlife Department's Marine Sport-Harvest Monitoring Program Metadata. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Fisheries Statistics Division (FSD). Miami, FL. 25 pp.

Nuttall, MA, K Dettloff, KE Fitzpatrick, K Brennan, and VM Matter. 2020. SEDAR 68-DW-31. SEFSC Computation of Uncertainty for Southeast Region Headboat Survey and Total Recreational Landings Estimates, with Application to SEDAR 68 Scamp and Yellowmouth Grouper. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Fisheries Statistics Division (FSD). Miami, FL.

SFD (Sustainable Fisheries Division). 2021a. SEDAR 68-RW-01. Modeling of Recreational Landings in Gulf Stock Assessments. National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Sustainable Fisheries Division (SFD) Gulf Branch. Miami, FL.

SFD. August 2021b. Adjustment of SEDAR 61 Gulf red grouper projected catch streams using Mean Weight of Recreationally Landed Fish from ACL Monitoring. Briefing Book: VIII. Review of Updated Red Grouper Interim Analysis. Attachment for August 2021 GSFMC SSC Meeting, Tampa, FL. Retrieved from: https://gulfcouncil.org/scientific-and-statistical-meetings/aug2021/