Modeling of recreational landings in Gulf stock assessments

Gulf Branch – Sustainable Fisheries Division

SEDAR68-RW-01

10 August 2021

This information is distributed solely for the purpose of pre-dissemination peer review. It does not represent and should not be construed to represent any agency determination or policy.

Please cite this document as:

Gulf Branch, Sustainable Fisheries Division 2021. Modeling of recreational landings in Gulf stock assessments. SEDAR68-RW-01. SEDAR, North Charleston, SC. 18 pp.

Modeling of Recreational Landings in Gulf Stock Assessments

Gulf Branch
Sustainable Fisheries Division
NOAA Fisheries - Southeast Fisheries Science Center

August 2021

Keywords

Scamp, Gulf of Mexico, SEDAR 68, Recreational Landings

Abstract

This document describes sensitivity runs conducted to evaluate how recreational landings are incorporated into Gulf stock assessments using Gulf of Mexico Scamp. Recreational landings can be input in either numbers of fish or in weights, and mean weight can be used either in the fitting process or as a check to ensure model results adequately characterize the size of landed fish.

Introduction

Traditionally, Gulf stock assessments have fit to recreational landings in numbers of fish because numbers are the native units of recreational monitoring surveys and have been historically provided. For example, the recreational Access Point Angler Intercept Survey (APAIS) is used primarily to estimate the mean numbers of fish harvested and released of different species per angler trip (NOAA 2019). While some weight information can be collected through the Marine Recreational Information Program (MRIP), corresponding weight measurements for all fish are not always available due to sampling constraints or incomplete self-reporting (Detloff and Matter 2019). The implementation of Annual Catch Limits (ACL) led to the development of standard methodology to develop weight estimates for use in monitoring ACLs (Matter and Turner 2010).

The SEDAR61 Red Grouper stock assessment model was completed in July 2019 and reviewed by the Gulf of Mexico Fishery Management Council at its October 2019 meeting. Overall, the SEDAR61 assessment model exhibited acceptable model performance and fits to data inputs, such as recreational landings in numbers of fish, age compositions of landed fish and length compositions of discarded fish. The adoption of catch advice recommended by SEDAR61 was delayed due to decisions requiring reallocation of Red Grouper between the commercial and recreational fisheries, which relied on time series of landings in weight units detailed further in Amendment 53 (GMFMC 2021). Additional analyses comparing recreational landings in weights used for ACL monitoring and SEDAR61 predicted (expected) recreational landings in

weights identified an inconsistency in the mean weight of Red Grouper landed by the recreational fishery, with the SEDAR61 assessment model underpredicting the weight of Scamp landed by the recreational fishery (SEFSC 2021). The mismatch in expected versus observed mean weight was not identified during the assessment process because the Standard SEDAR61 Data/Assessment Workshop focused solely on recreational landings in numbers, as traditionally done in Gulf assessments. Ultimately, this occurred due to the configuration of the model, which used length-based selectivity and an externally calculated growth curve (with an assumed coefficient of variability at age), which led to the mismatch in weight-at-age.

The purpose of this working paper is to demonstrate the sensitivity of model results by incorporating recreational landings in either numbers of fish or weights and including data on mean weight of Scamp landed by the recreational fleets. Mean weight data were used as either a check on the assessment expected mean weight of landed Scamp or were fit directly in the stock assessment model.

Materials and Methods

Modeling Mean Weight in Stock Synthesis

Annual mean weight of Scamp landed by each recreational fleet (Recreational Charter Private and Recreational Headboat) was incorporated into sensitivity runs for the SEDAR 68 ADT Base Model developed by the SEDAR68 Assessment Development Team (ADT). Stock Synthesis requires body weight data in units of kilograms and error estimates in terms of the coefficient of variation (CV) of the observed mean weight (Methot et al. 2020).

Mean Weight Observed in Recreational Datasets

Mean weight of Scamp landed by the recreational fleets were available from Marine Recreational Information Program, formerly the Marine Recreational Fisheries Statistics Survey, and the Southeast Region Headboat Survey (SRHS). Annual estimates of mean weight in pounds whole weight were obtained from MRIP (Table 11 in SEDAR 68-DW-09) and in kilograms whole weight from the SRHS (Table 4.12.7 of the SEDAR 68 DW Report). These values were converted into kilograms gutted weight for input into the Stock Synthesis model using the conversion of whole weight to gutted weight ($GWT = WWT * 0.95$; Table 12 in SEDAR 68 DW Report) and pounds to kilograms (1 pound = 0.453592 kilogram; **Table 1**).

Estimates of error were not reported for either MRIP or SRHS in either document identified above. For the observed mean weight from MRIP, annual standard deviations (SD) were extracted from the raw data file submitted for SEDAR 68 and converted into CVs (**Table 1**). Due to the lack of an error estimate for the SRHS, the average error value for the MRIP data of CV = 0.67 (mean of 1981-2017) was used as a placeholder.

Derived Mean Weight - Estimated Weights Divided by Numbers

Mean weight of Scamp landed by each recreational fleet were also developed by dividing the estimates of recreational landings in weights by the recreational landings in numbers to get an average size (**Table 2**). Since no estimates of error were available, we assumed the error estimates from the observed data discussed above were a good proxy of uncertainty.

Sensitivity Runs

Sensitivity runs were conducted with the SEDAR 68 ADT Base Model to investigate critical uncertainty in data and reactivity to modeling assumptions. Focus of the sensitivity runs was on population trajectories and important parameter estimates (e.g., recruitment).

Treatment of Recreational Landings - Input of recreational landings was a key discussion point during the SEDAR 68 AP and other recent assessments. Six sensitivity runs were conducted:

1. *Include mean weight (observed) for comparison purposes only in the SEDAR 68 ADT Base Model*. This run included the observed mean weight for each recreational fleet but did not fit to these data. This allowed a comparison between the assessment model expected mean weight and the mean weight of Scamp landed by each recreational fleet.
2. *Include mean weight (derived via estimated weight/number) for comparison purposes only in the SEDAR 68 ADT Base Model*. This run included the mean weight derived by dividing the estimates of recreational landings in weights by the numbers for each recreational fleet but did not fit to these data. This allowed a comparison between the assessment model expected mean weight and the mean weight of Scamp landed by each recreational fleet.
3. *Include and fit to mean weight (observed)*. This run included the observed mean weight for each recreational fleet and fit to these data.
4. *Include and fit to mean weight (derived via estimated weight/number)*. This run included the mean weight derived by dividing the estimates of recreational landings in weights by the numbers for each recreational fleet and fit to these data.
5. *Include and fit to both recreational landings in numbers and mean weight (observed)*. This run inputted recreational landings in numbers of fish and the observed mean weight for each recreational fleet and fit to these data.
6. *Include and fit to both recreational landings in numbers and mean weight (derived via estimated weight/number)*. This run inputted recreational landings in numbers of fish and the mean weight derived by dividing the estimates of recreational landings in weights by the numbers for each recreational fleet and fit to these data.

Results

Comparison of Observed versus Derived Mean Weight

The observed mean weight each year was generally very similar to the derived mean weight (weights/numbers) for the Recreational Charter Private fleet, withthe exception of the first few years of data where the observed weight was lower (**Figure 1**). In contrast, the Recreational Headboat fleet showed more variability in observed versus derived mean weight (weights/numbers), with higher observed mean weight in 2008 and the more recent years (**Figure 2**).

Assessment Model Expected vs Observed Mean Weight for the SEDAR 68 ADT Base Model

The SEDAR 68 ADT Base Model expected mean weights were generally similar to observed or derived mean weights for both the Recreational Charter Private fleet (observed: **Figure 3**, derived: **Figure 4**) and the Recreational Headboat fleet (observed: **Figure 5**, derived: **Figure 6**). All expected mean weights remained within the confidence intervals for the observed data. The observed and derived mean weights exhibited more variability than the mean weight expected by the assessment model.

Assessment Model Expected vs Observed Mean Weight for Base Model fitting to Mean Weight

When fitting to the mean weight for both recreational fleets, no major deviations in mean weight were observed (**Figures 7-10**). Overall, estimates of key parameter estimates were similar to the SEDAR 68 ADT Base Model (**Table 3**).

Assessment Model Expected vs Observed Mean Weight for Model fitting to Numbers and Mean Weight

When fitting to both recreational landings in numbers and to mean weight of Scamp landed by the recreational fleets, assessment model expected mean weights were similar to observed or derived mean weights for both the Recreational Charter Private fleet (observed: **Figure 11**, derived: **Figure 12**) and the Recreational Headboat fleet (observed: **Figure 13**, derived: **Figure 14**). Similar to above, the observed and derived mean weights exhibited more variability than the mean weight expected by the assessment model.

Fitting to recreational landings in numbers (and to mean weight of Scamp landed by the recreational fleets) led to some small differences in estimated parameters such as a slightly higher steepness estimate (0.961 vs 0.949), a lower estimate of unfished recruitment on a log-scale (LN(R_0) of 7.357 vs 7.433), and lower virgin spawning stock biomass (SSB ~3,600 vs 3,900 metric tons; **Table 3**). SSB was lower throughout much of the time series, and fell outside the confidence interval for the SEDAR 68 ADT Base Model in the most recent years **Figure 15**. Recruitment estimates also showed some variability, with lower estimates from 2003 until most recent years, although these estimates did not fall outside the confidence intervals for the SEDAR 68 ADT Base Model (**Figure 15**). Fitting to recreational numbers (and mean weight of Scamp landed by the recreational fleets) led to lower fishing mortality rates in the 1980s and higher fishing mortality rates for many years after 2004 (**Figure 15**).

Discussion

This analysis was motivated by the mismatch in terms of how recreational landings have traditionally been incorporated into assessments (i.e., numbers) versus what recreational landings have been used for ACL monitoring (i.e., weights) for Red Grouper. For Scamp, this analysis demonstrates the different approaches that could be taken for incorporating recreational landings data into stock assessments. While the different approaches that could be taken for incorporating recreational landings data into stock assessments were evaluated for Scamp, there is a clear need to develop best practices for modeling recreational landings in Gulf stock assessments.

Traditional model selection is not feasible due to changes in input data, either between recreational landings in numbers or weights or in observed mean weights (i.e., **Table 1**) or derived mean weights (**Table 2**). The most straightforward way to better align the assessment with monitoring would be to input recreational landings in weights and ensure the mean weight of fish landed by each recreational fleet adequately match the mean weight derived from the ACL monitoring dataset. However, inputting and fitting to recreational landings in numbers is in line with the native units of the recreational surveys.

Future Data Workshops should review and provide mean weight of landed fish along with uncertainty measurements for each fleet (or dataset) to enable comparison of observed trends with assessment model expected trends. This analysis considered both observed mean weight, as measured by each survey, and a derived mean weight, obtained by dividing the recreational landings estimates in weight by the estimates in numbers. Discussions of which data streams are most appropriate to characterize mean weight of landed (and discarded) fish should become regular tasks during Data Workshops. In addition, comparisons between observed and assessment expected quantities such as mean weight should become common analyses accompanying any stock assessment.

References

Dettloff, K and V. Matter. 2019. Sample size sensitivity analysis for calculating MRIP weight estimates. SEDAR67-WP-06. SEDAR, North Charleston, SC. 6 pp. Available at: *http://sedarweb.org/docs/wpapers/S67_WP_06_MRIP_weight_Sample_size.pdf*

Gulf of Mexico Fishery Management Council (GMFMC). 2021. Revised Draft Reef Fish Amendment 53. Red Grouper Allocations and Annual Catch Levels and Targets. National Marine Fisheries Service, NA15NMF4410011, Tampa, Florida.

Matter, VM and SC Turner. 2010. Estimated recreational catch in weight: method for filling in missing weight estimates from the recreational surveys with application to yellowedge grouper, tilefish (golden), and blueline tilefish. Sustainable Fisheries Division Contribution No. SFD-2010-003. Miami, FL. SEDAR 22-DW-16. Available at: *http://sedarweb.org/docs/wpapers/S22_DW_16_Est_Rec_Catch_in_Weight.pdf*

Methot RD, CR Wetzel, IG Taylor and K Doering. 2020. Stock Synthesis User Manual Version 3.30.16. NOAA Fisheries, Seattle Washington. 225 pp.

NOAA Fisheries. 2019. Recommended use of the current Gulf of Mexico surveys of marine recreational fishing in stock assessments. 32 pp. Available at: *http://sedarweb.org/docs/wsupp/S70_RD_03_MRIP_State_survey_white_paper.pdf*

Tables

Table 1. Mean weight (MW) of Scamp landed by the Recreational Charter Private (CP) and Recreational Headboat (HBT) fleets in whole weight (wwt) and gutted weight (gwt) in pounds (lbs) and kilograms (kg). Gray shaded columns identify converted estimates input into Stock Synthesis.

Year	CP MW (lbs wwt)	CP SD (lbs wwt)	CP MW (kg gwt)	CP (CV)	HBT MW (kg wwt)	HBT MW (kg gwt)
1986	3.868	2.092	1.667	0.541	1.34	1.273
1987	3.572	3.158	1.539	0.884	1.65	1.567
1988	2.528	1.442	1.089	0.570	1.31	1.244
1989	4.237	2.173	1.826	0.513	1.14	1.083
1990	3.388	2.209	1.460	0.652	1.38	1.311
1991	3.252	1.958	1.401	0.602	1.03	0.978
1992	4.543	2.398	1.958	0.528	1.09	1.036
1993	4.917	2.731	2.119	0.555	1.18	1.121
1994	4.045	2.259	1.743	0.558	1.20	1.140
1995	3.439	1.493	1.482	0.434	1.33	1.264
1996	5.150	2.301	2.219	0.447	1.76	1.672
1997	7.033	3.661	3.031	0.521	1.06	1.007
1998	6.121	3.766	2.638	0.615	2.30	2.185
1999	4.143	3.491	1.785	0.843	1.30	1.235
2000	4.305	3.689	1.855	0.857	1.96	1.862
2001	4.683	3.415	2.018	0.729	1.65	1.567
2002	3.729	2.473	1.607	0.663	1.16	1.102
2003	3.456	2.707	1.489	0.783	1.42	1.349
2004	2.972	2.305	1.281	0.776	0.96	0.912
2005	3.002	2.452	1.294	0.817	1.46	1.387
2006	3.222	2.537	1.388	0.787	1.70	1.615
2007	2.964	1.932	1.277	0.652	1.45	1.378
2008	3.541	2.096	1.526	0.592	2.74	2.603
2009	4.217	2.865	1.817	0.679	1.44	1.368
2010	3.330	2.583	1.435	0.776	2.05	1.947
2011	2.595	1.102	1.118	0.425	0.97	0.921

Table 1 Continued. Mean weight (MW) of Scamp landed by the Recreational Charter Private (CP) and Recreational Headboat (HBT) fleets in whole weight (wwt) and gutted weight (gwt) in pounds (lbs) and kilograms (kg). Gray shaded columns identify converted estimates input into Stock Synthesis.

Year	CP MW (lbs wwt)	CP SD (lbs wwt)	CP MW (kg gwt)	CP (CV)	HBT MW (kg wwt)	HBT MW (kg gwt)
2012	3.359	1.681	1.447	0.500	2.15	2.042
2013	3.879	2.474	1.672	0.638	2.04	1.938
2014	3.394	2.127	1.463	0.627	1.89	1.795
2015	3.456	2.064	1.489	0.597	2.13	2.023
2016	4.303	2.224	1.854	0.517	2.18	2.071
2017	4.486	2.635	1.933	0.587	1.76	1.672

Table 2. Recreational landings by the Recreational Charter Private fleet in gutted weights (gwt) and numbers (N) for Gulf of Mexico Scamp. The derived mean weight (MWlbs, pounds gutted weight or MWkg, kilograms gutted weight) was determined by dividing the recreational landings in weights by the numbers of fish for each recreational fleet. Gray shaded columns identify converted estimates input into Stock Synthesis.

Year	CP (gwt)	CP (N)	CP (MWlbs)	CP (MWkg)	HBT (gwt)	HBT (N)	HBT (MWlbs)	HBT (MWkg)
1986	193,684	47,774	4.054	1.839	17,095	7,263	2.354	1.068
1987	265,306	68,515	3.872	1.756	11,113	4,577	2.428	1.101
1988	137,767	39,526	3.485	1.581	8,117	3,399	2.388	1.083
1989	81,639	18,610	4.387	1.990	22,966	9,310	2.467	1.119
1990	22,450	6,523	3.441	1.561	6,586	2,388	2.758	1.251
1991	45,782	14,872	3.078	1.396	7,136	2,056	3.471	1.574
1992	57,686	13,651	4.226	1.917	3,997	1,611	2.481	1.126
1993	122,137	23,433	5.212	2.364	3,916	1,685	2.325	1.054
1994	50,417	12,868	3.918	1.777	2,791	1,137	2.455	1.113
1995	14,931	4,329	3.449	1.564	3,529	1,370	2.576	1.168
1996	42,373	12,313	3.441	1.561	2,359	813	2.903	1.317
1997	99,232	14,719	6.742	3.058	2,707	1,165	2.324	1.054
1998	128,266	20,732	6.187	2.806	4,809	1,241	3.876	1.758

Table 2 Continued. Recreational landings by the Recreational Charter Private fleet in gutted weights (gwt) and numbers (N) for Gulf of Mexico Scamp. The derived mean weight (MWlbs, pounds gutted weight or MWkg, kilograms gutted weight) was determined by dividing the recreational landings in weights by the numbers of fish for each recreational fleet.

Year	CP (gwt)	CP (N)	CP (MWlbs)	CP (MWkg)	HBT (gwt)	HBT (N)	HBT (MWlbs)	HBT (MWkg)
1999	150,796	39,729	3.796	1.722	2,596	1,064	2.440	1.107
2000	41,710	10,562	3.949	1.791	4,185	1,028	4.072	1.847
2001	61,221	13,574	4.510	2.046	1,686	616	2.737	1.242
2002	88,109	24,462	3.602	1.634	1,731	705	2.457	1.114
2003	150,048	45,392	3.306	1.499	1,773	675	2.628	1.192
2004	130,639	52,107	2.507	1.137	2,856	1,315	2.172	0.985
2005	162,094	61,283	2.645	1.200	2,121	1,075	1.973	0.895
2006	308,116	105,390	2.924	1.326	2,447	589	4.155	1.885
2007	97,499	40,460	2.410	1.093	2,238	668	3.351	1.520
2008	236,321	59,848	3.949	1.791	1,964	608	3.231	1.466
2009	192,097	49,246	3.901	1.769	1,348	598	2.256	1.023
2010	84,972	27,406	3.100	1.406	3,696	992	3.726	1.690
2011	105,012	43,948	2.389	1.084	4,176	815	5.124	2.324
2012	220,667	76,191	2.896	1.314	3,454	1,096	3.152	1.430
2013	253,100	77,149	3.281	1.488	4,237	1,388	3.053	1.385
2014	253,710	76,335	3.324	1.508	6,613	2,100	3.149	1.429
2015	328,997	105,993	3.104	1.408	8,779	2,613	3.360	1.524
2016	236,913	68,551	3.456	1.568	5,480	1,730	3.168	1.437
2017	185,200	46,443	3.988	1.809	4,108	1,537	2.673	1.213

Table 3. Summary of sensitivity runs conducted for the Gulf of Mexico Scamp SEDAR 68 ADT Base Model concerning recreational landings inputs. NLL = negative log-likelihood, R0 = unfished recruitment on log-scale, SSB = spawning stock biomass, mt = metric tons, and Recr = recruitment. Note that likelihoods are not directly comparable due to changes in the data.

Description	NLL	Gradient	Estimated Parameters (Bounded)	Parameters with CV>1
SEDAR 68 ADT Base	16,650.5	0.0022	220 (1)	14
+ mean weight (observed)	16,656.1	0.1211	220 (1)	14
+ mean weight (derived)	16,653.7	0.0402	220 (0)	14
Recreational Landings in Numbers	16,640.0	0.0166	220 (0)	15
+ mean weight (observed)	16,645.7	0.0030	220 (0)	15
+ mean weight (derived)	16,643.2	0.0065	220 (0)	15

Description	Steepness	SigmaR	Ln(R0)	Virgin SSB (mt)	Virgin Recr (1,000s)
SEDAR 68 ADT Base	0.949	0.356	7.433	3,910.65	1,691.01
+ mean weight (observed)	0.949	0.355	7.433	3,910.44	1,691.00
+ mean weight (derived)	0.949	0.355	7.433	3,909.96	1,690.89
Recreational Landings in Numbers	0.961	0.358	7.357	3,622.10	1,567.08
+ mean weight (observed)	0.961	0.358	7.357	3,620.28	1,566.37
+ mean weight (derived)	0.961	0.358	7.356	3,619.36	1,566.06

Description	Catch	EqCatch	Survey	Discard	MW	Length	Age
SEDAR 68 ADT Base	32.5	0.2	-47.3	34.6	-	6,831.5	9,774.5
+ mean weight (observed)	32.5	0.2	-47.4	34.6	5.6	6,831.2	9,774.9
+ mean weight (derived)	32.5	0.2	-47.3	34.5	3.1	6,831.3	9,774.9
Recreational Landings in Numbers	28.6	0.2	-45.0	26.0	-	6,826.6	9,776.0
+ mean weight (observed)	28.6	0.2	-45.1	26.1	5.6	6,826.2	9,776.4
+ mean weight (derived)	28.6	0.2	-45.1	26.0	3.2	6,826.3	9,776.4

Figures

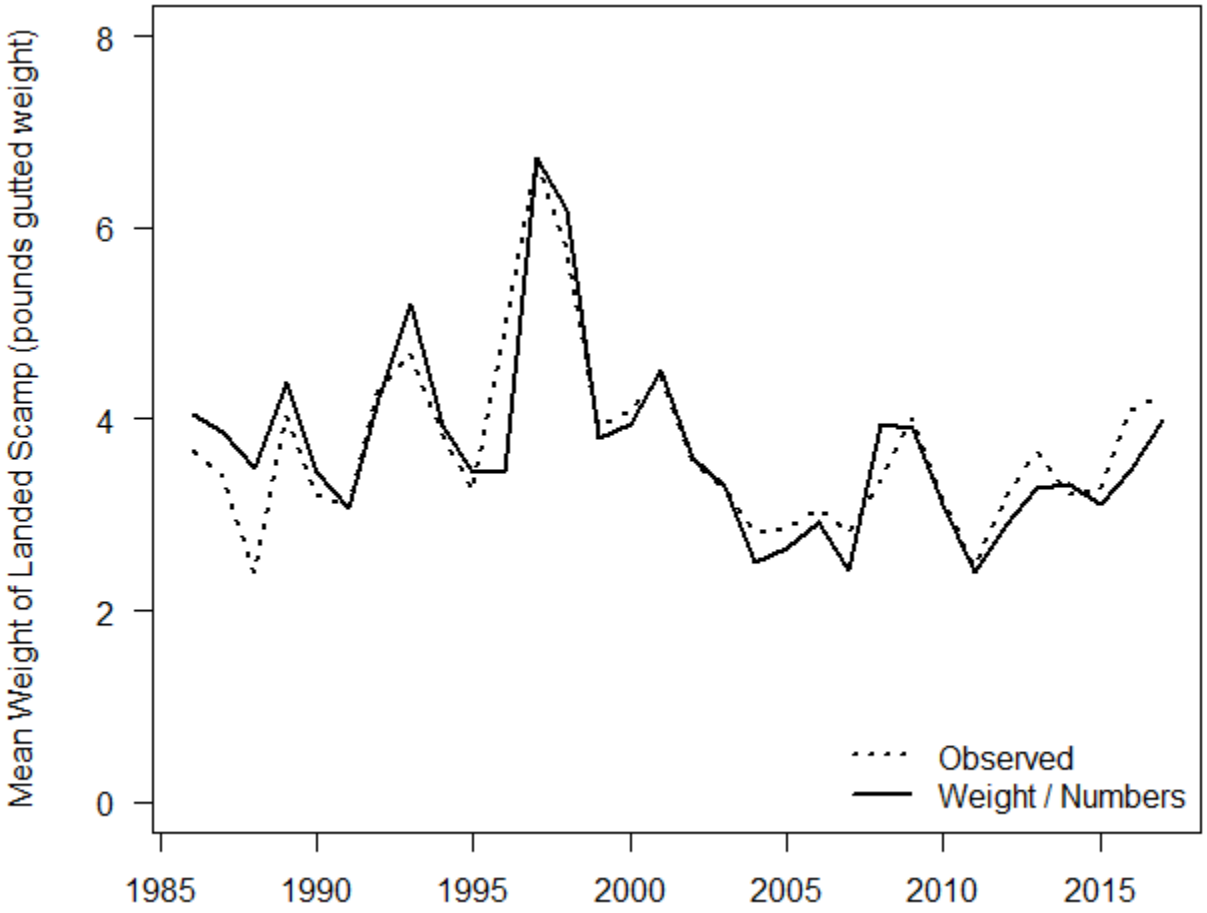

Figure 1. Comparison of mean weight of Scamp landed by the Recreational Charter Private fleet in the Gulf of Mexico based on observed data and derived mean weight (weight divided by numbers).

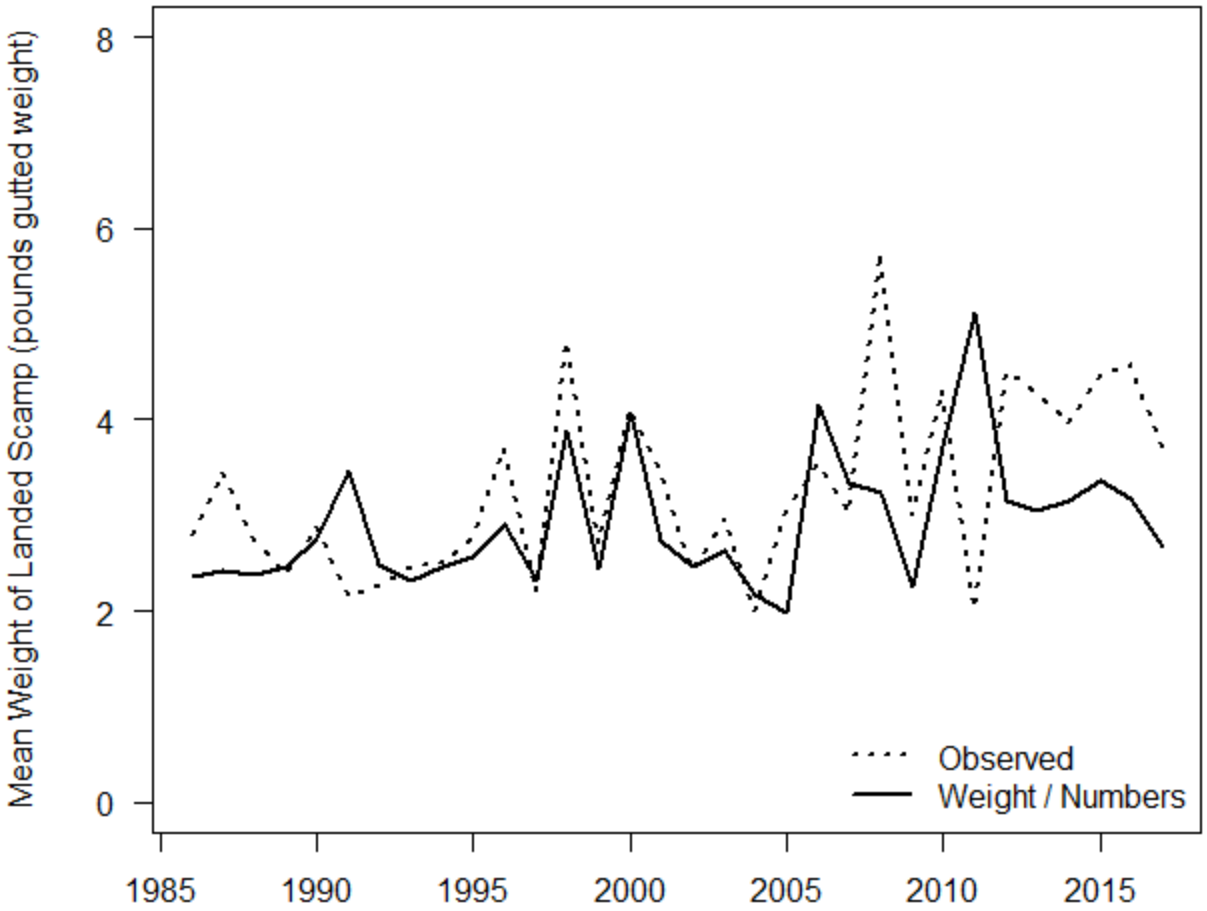

Figure 2. Comparison of mean weight of Scamp landed by the Recreational Headboat fleet in the Gulf of Mexico based on observed data and derived mean weight (weight divided by numbers).

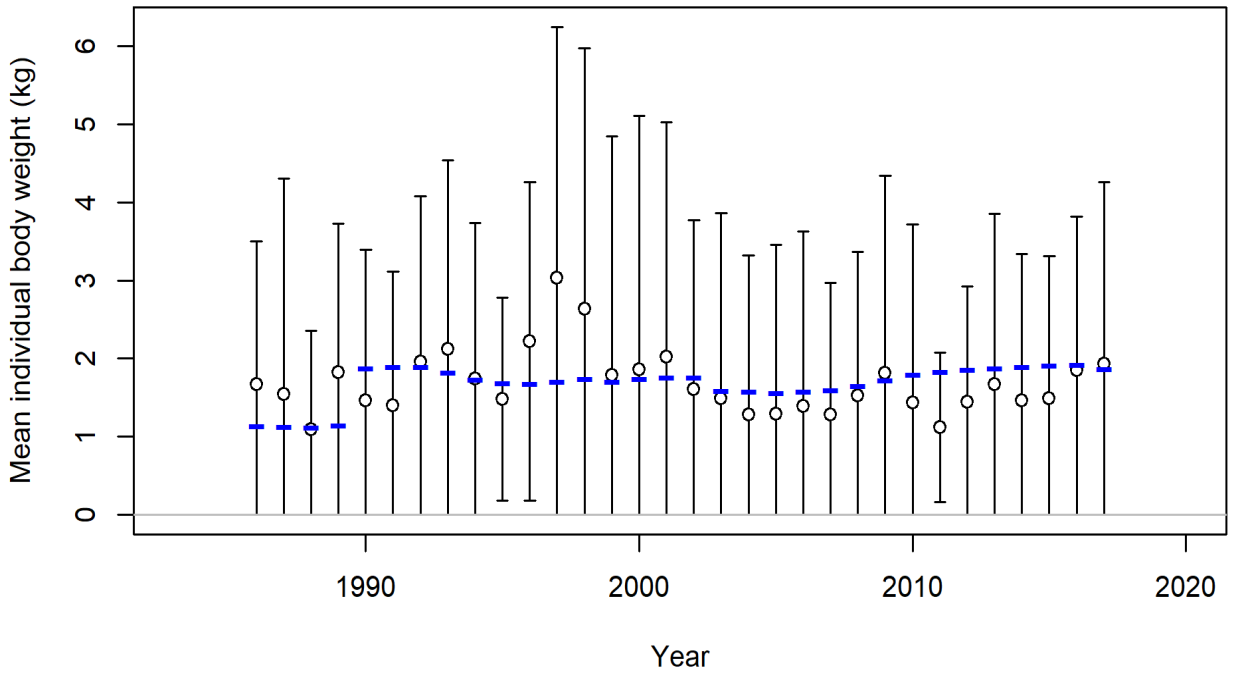

Figure 3. Input (observed mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Charter Private fleet in the Gulf of Mexico. This run is the SEDAR 68 ADT Base Model (fit to the recreational landings in weights) but does not fit to the mean weight of Scamp landed by each recreational fleet.

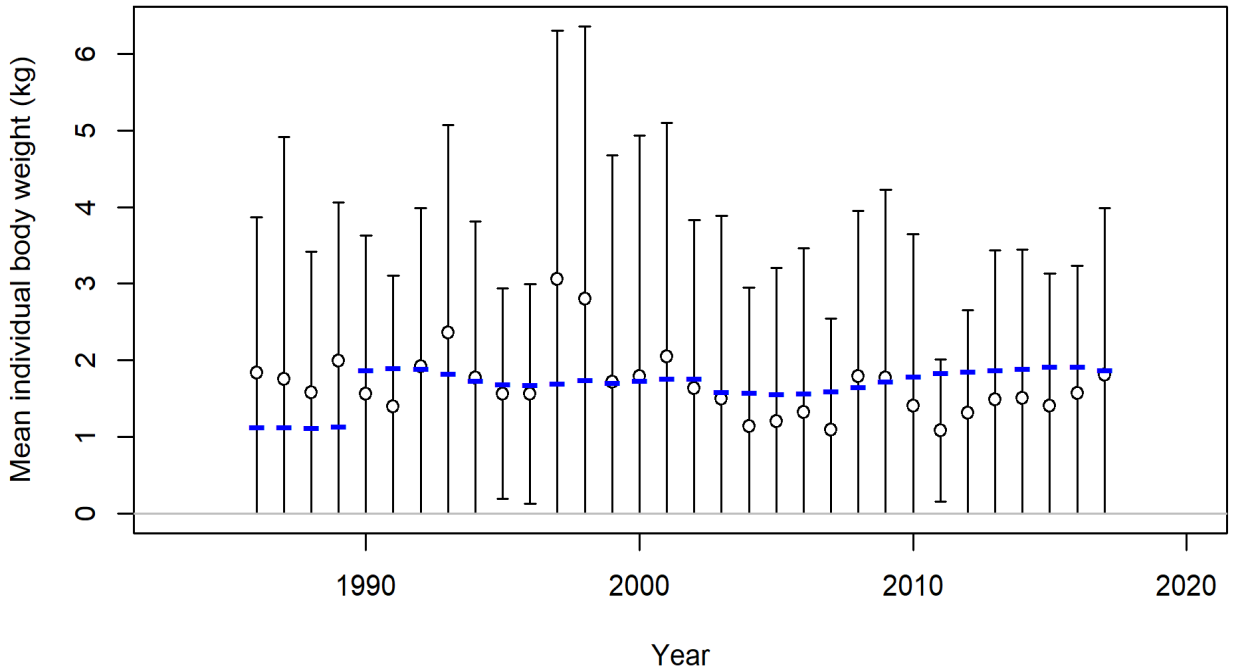

Figure 4. Input (derived mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Charter Private fleet in the Gulf of Mexico. This run is the SEDAR 68 ADT Base Model (fit to the recreational landings in weights) but does not fit to the mean weight of Scamp landed by each recreational fleet.

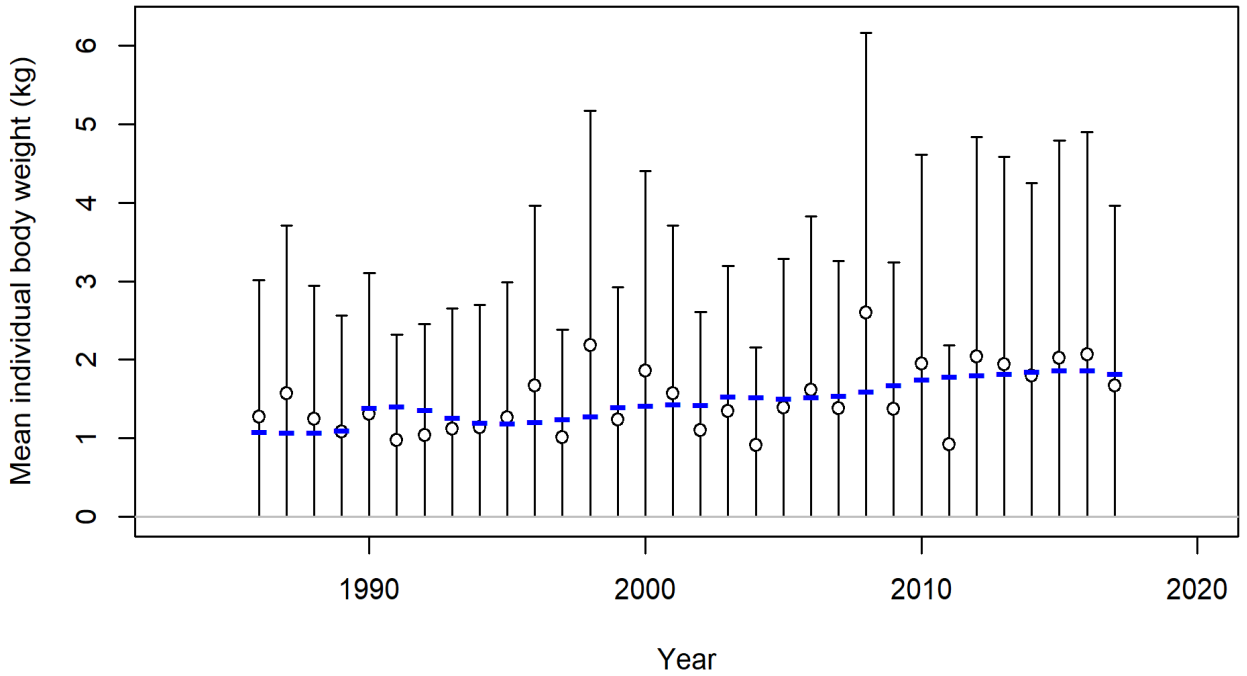

Figure 5. Input (observed mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Headboat fleet in the Gulf of Mexico. This run is the SEDAR 68 ADT Base Model (fit to the recreational landings in weights) but does not fit to the mean weight of Scamp landed by each recreational fleet.

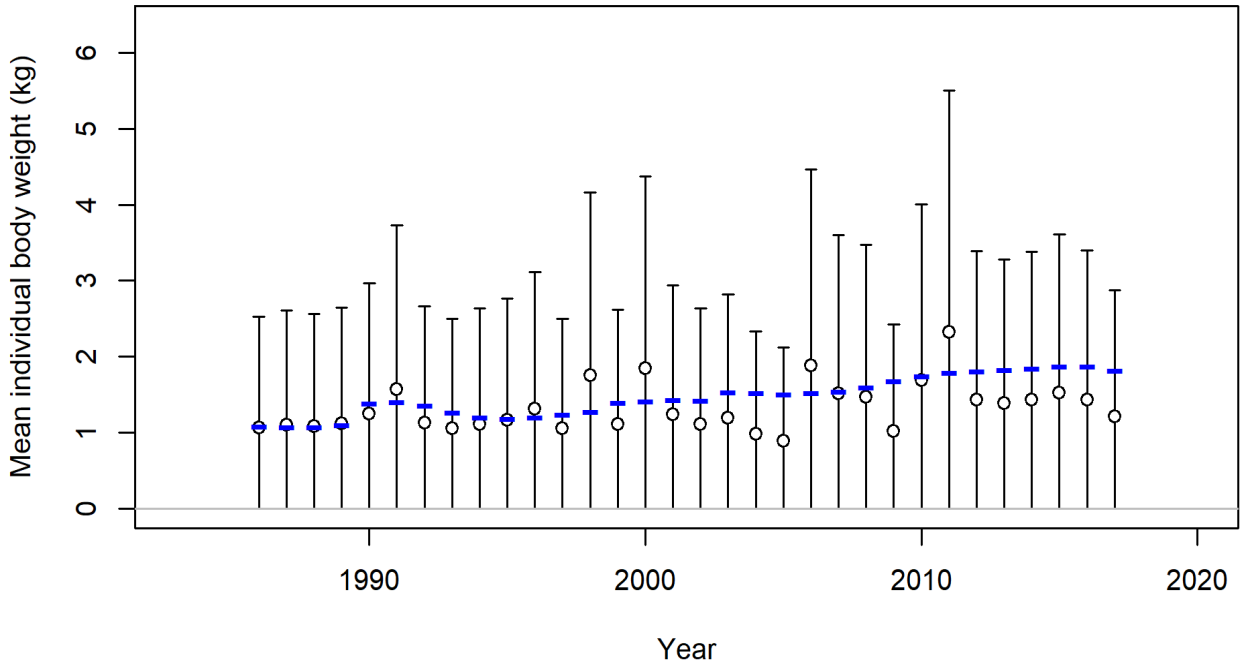

Figure 6. Input (derived mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Headboat fleet in the Gulf of Mexico. This run is the SEDAR 68 ADT Base Model (fit to the recreational landings in weights) but does not fit to the mean weight of Scamp landed by each recreational fleet.

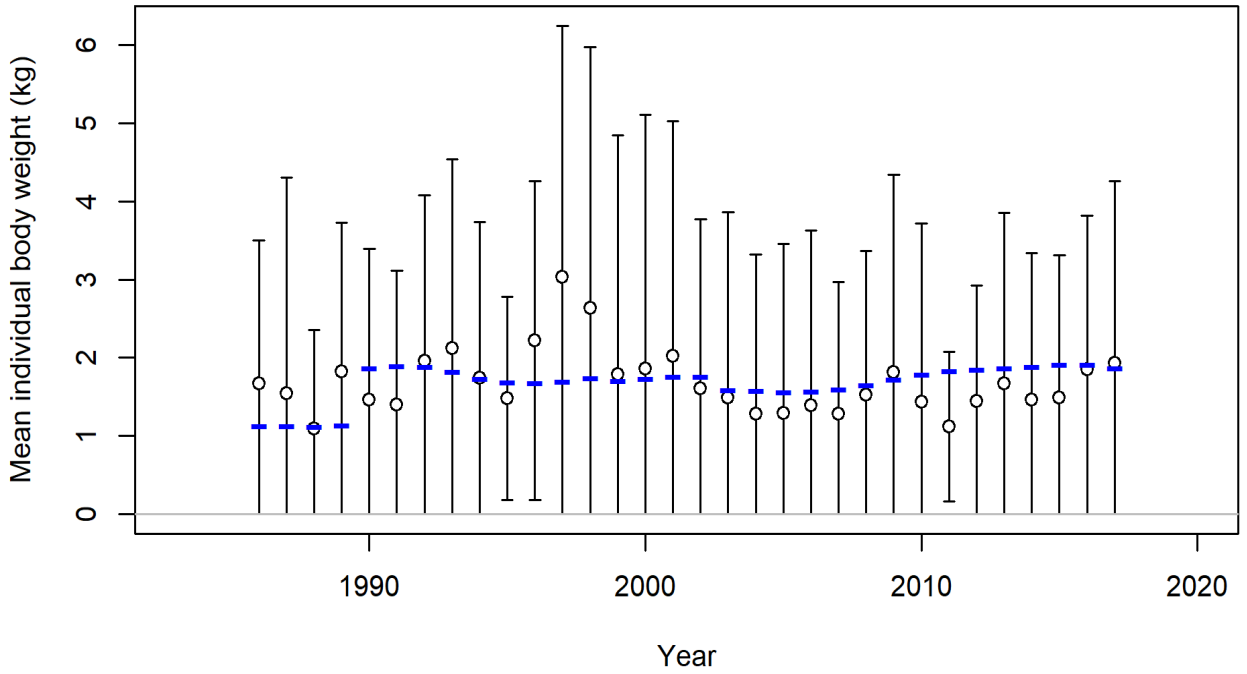

Figure 7. Input (observed mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Charter Private fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in weights and the mean weight of landed Scamp for each recreational fleet.

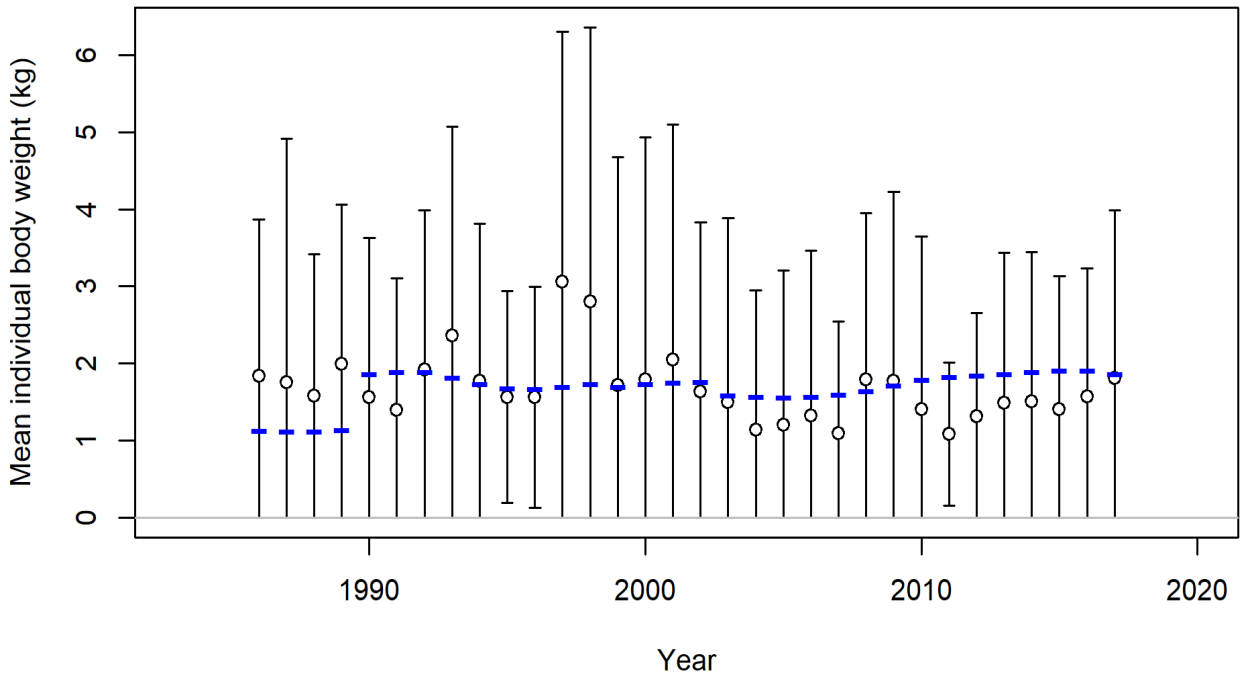

Figure 8. Input (derived mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Charter Private fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in weights and the mean weight of landed Scamp for each recreational fleet.

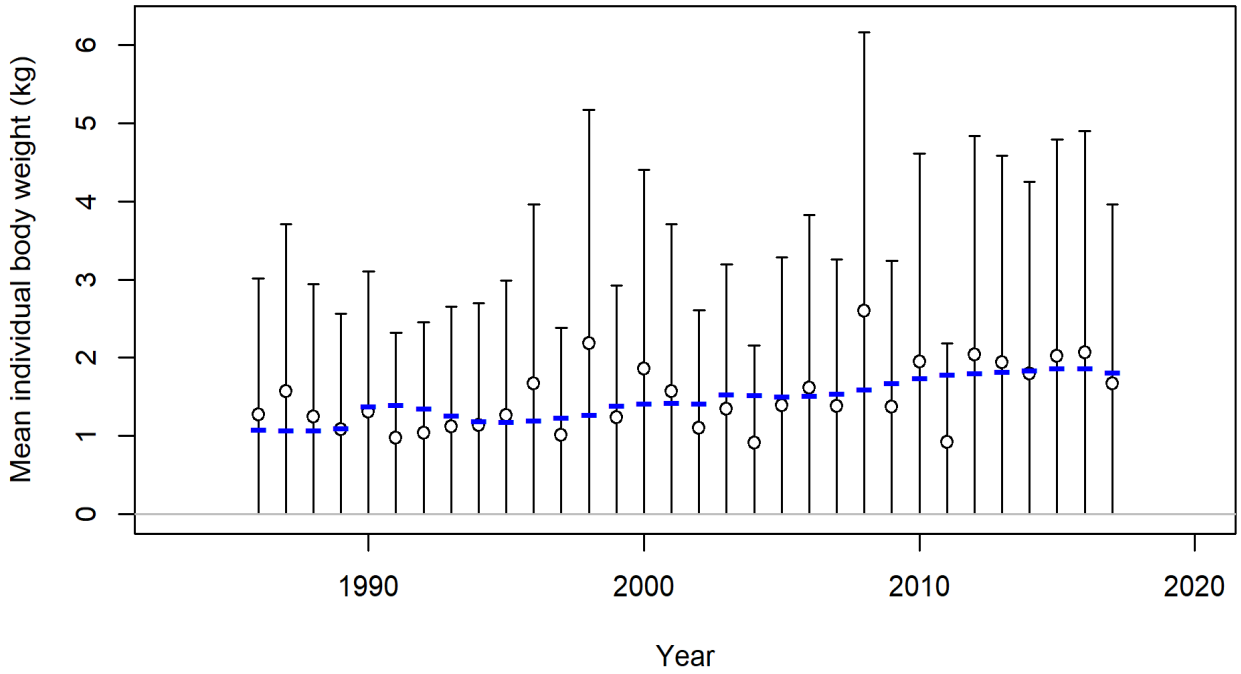

Figure 9. Input (observed mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Headboat fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in weights and the mean weight of landed Scamp for each recreational fleet.

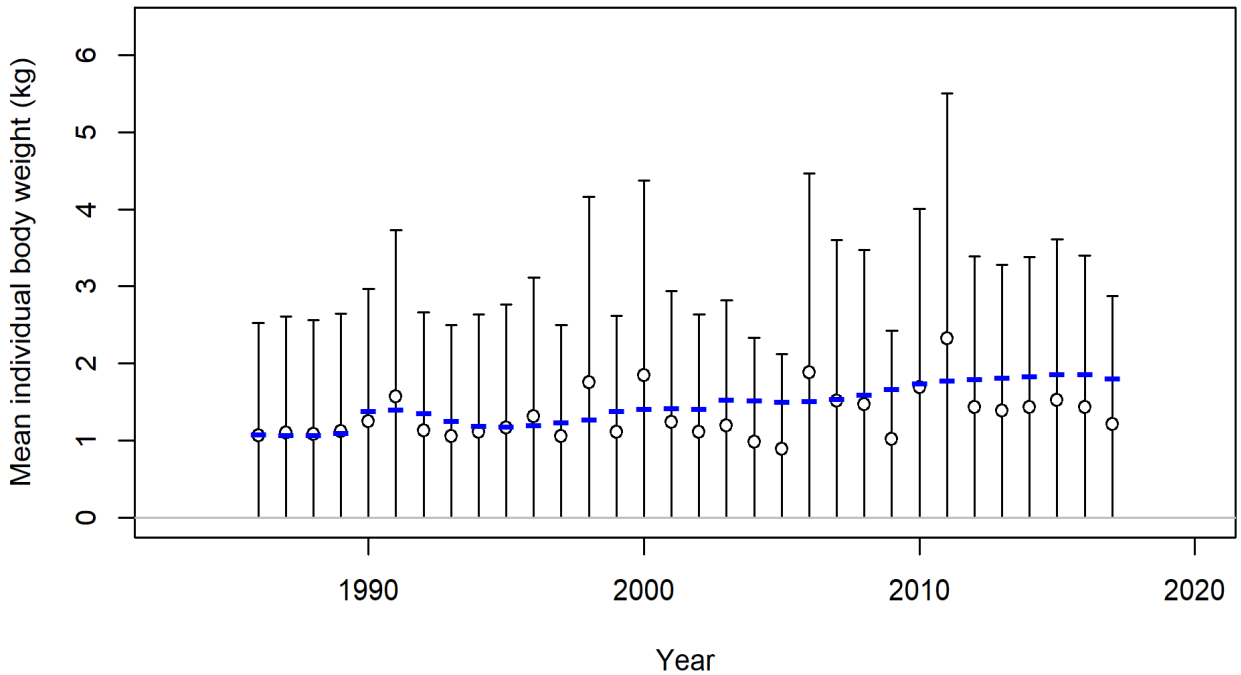

Figure 10. Input (derived mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Headboat fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in weights and the mean weight of landed Scamp for each recreational fleet.

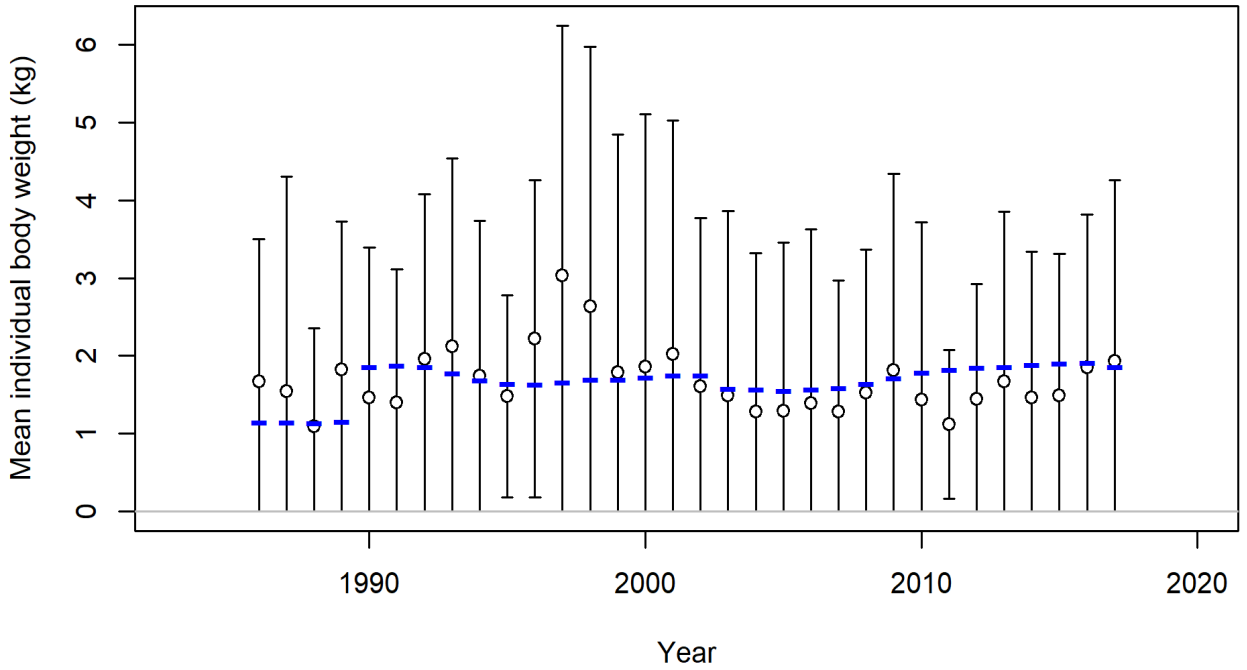

Figure 11. Input (observed mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Charter Private fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in numbers and the mean weight of landed Scamp for each recreational fleet.

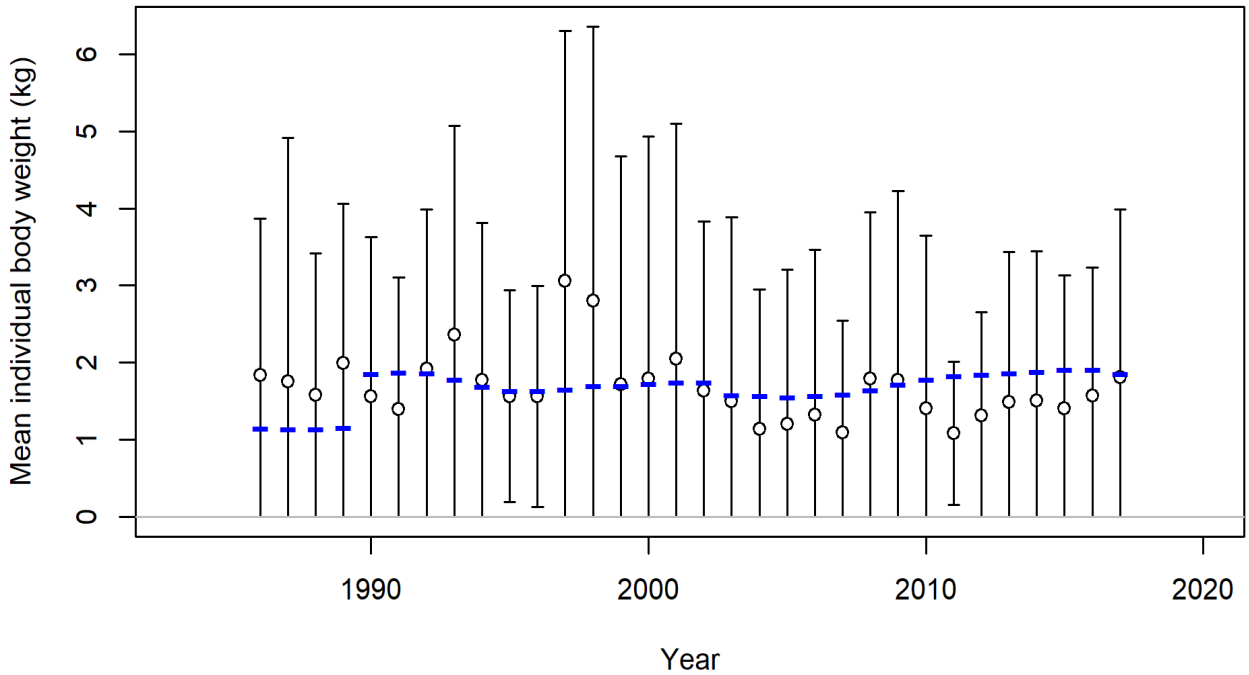

Figure 12. Input (derived mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Charter Private fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in numbers and the mean weight of landed Scamp for each recreational fleet.

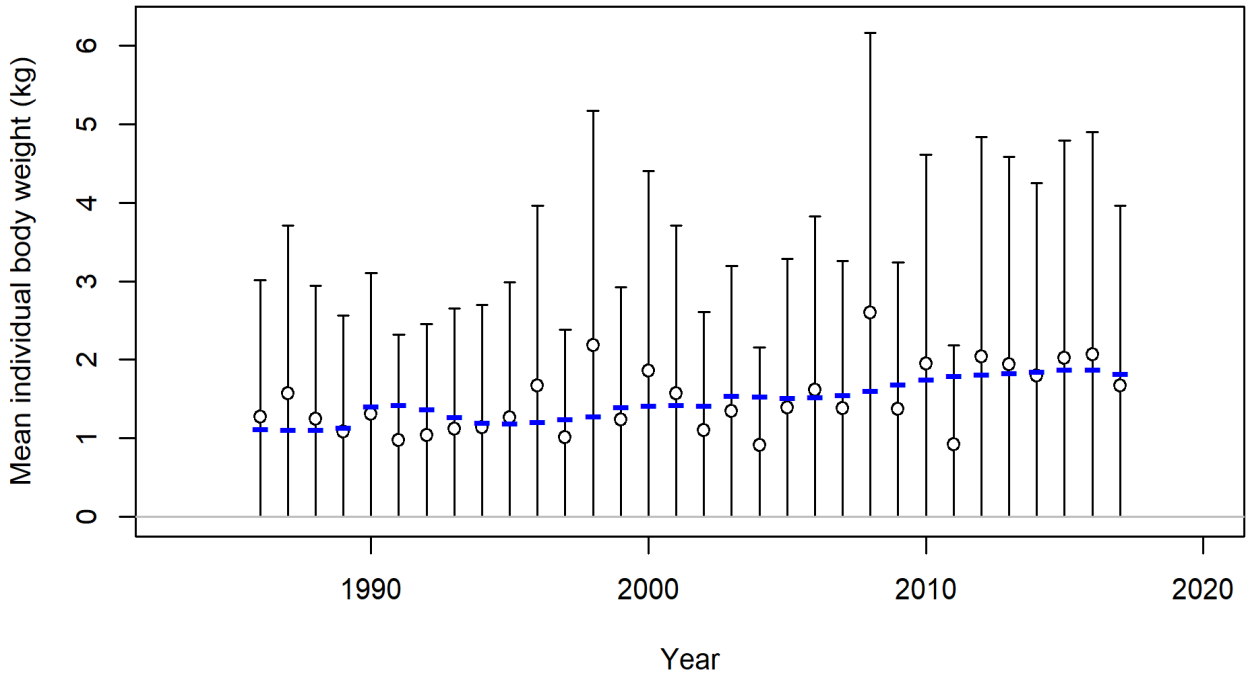

Figure 13. Input (observed mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Headboat fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in numbers and the mean weight of landed Scamp for each recreational fleet.

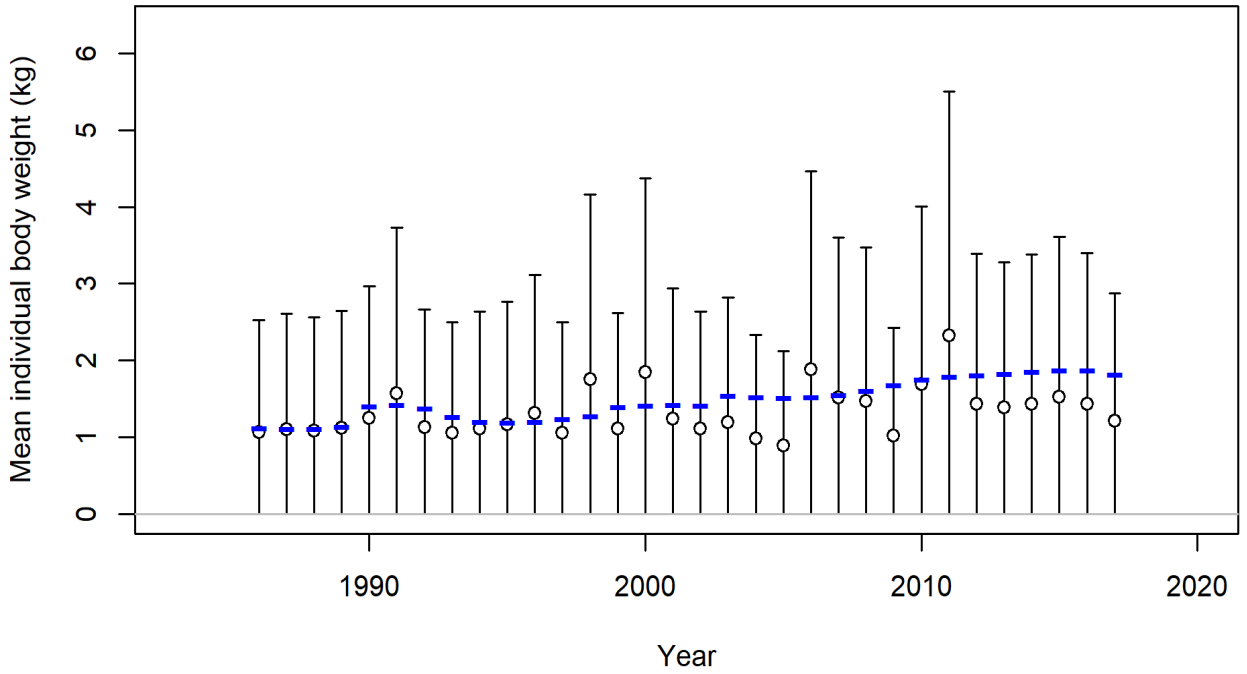

Figure 14. Input (derived mean weight; dots with 95% confidence intervals) and expected (blue lines) mean weight of Scamp landed by the Recreational Headboat fleet in the Gulf of Mexico. This sensitivity run fit to both the recreational landings in numbers and the mean weight of landed Scamp for each recreational fleet.

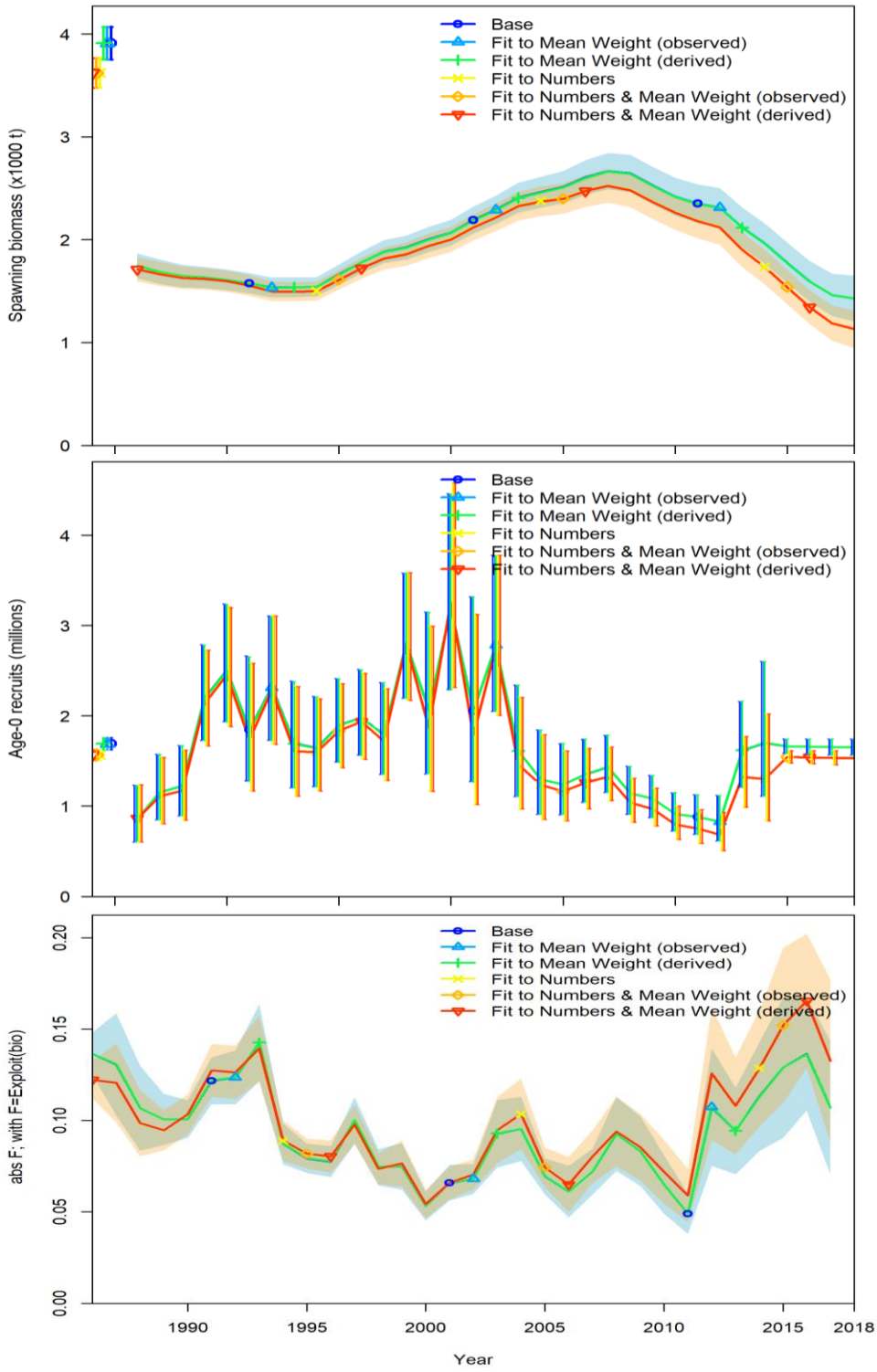

Figure 15. Estimates of spawning stock biomass (1,000s of metric tons; top panel), recruitment (millions of fish; middle panel), and fishing mortality (total biomass killed age 3+ / total biomass age 3+; bottom panel) for the sensitivity runs evaluating the treatment of recreational landings conducted for Gulf of Mexico Scamp.