Texas A&M University Corpus Christi

Harte Research Institute for Gulf of Mexico Studies

6300 Ocean Drive, Unit 5869
Corpus Christi, Texas 78412-5869
O 361.825.2000 • F 361.825.2050

Gregory W. Stunz, Ph.D.
Endowed Chair and Professor,
Harte Research Institute for Gulf of Mexico Studies,
6300 Ocean Drive, Harte Research Institute,
Corpus Christi, TX 78412-5869

August 16, 2021

Dear Dr. LaDon Swann and Mississippi-Alabama Sea Grant Consortium:

As you are well aware, the Gulf of Mexico Fishery Management Council's Gulf of Mexico Scientific and Statistical Committee (SSC) recently conducted a written and live peer-review of our report entitled, Estimating the Absolute Abundance of Age-2+ Red Snapper (*Lutjanus campechanus*) in the U.S. Gulf of Mexico, commonly known and often referred to as the "*Great Red Snapper Count*."

The three-day peer-review was a very valuable process, ultimately resulting in a determining vote by the external review team and members of the Standing SSC as Best Scientific Information Available. We would like to thank the independent external review team of Drs. Steve Cadrin, Mary Christman, and David Eggleston for their hard work in performing such an extensive constructive review of this very large study. Their insight on the design, analyses, and interpretation substantially improved this final report. Additionally, input from the Gulf of Mexico Fishery Management Council's SSC on earlier versions helped to refine various aspects of the study as it related to providing management advice.

During the course of the review, the external reviewers and the SSC made important analytical, editorial, and general suggestions and recommended additional analytical approaches to improve the study. The scientific team has worked diligently to reanalyze these data and were able to fully address the review team's suggestions and recommendations. Namely, carefully describing the stratified random sampling design, capturing as much additional variability as possible (including the addition of variance buffers when it was not mathematically possible to provide a variance estimate), modification of post-stratification, improving estimators, calibrations, reevaluating the contribution of Uncharacterized Bottom (UCB; the habitat type harboring the majority of Red Snapper), and correcting minor inconsistencies with sample sizes and other minor editorial changes. This included developing an alternative estimator of variance to capture the additional uncertainty of calibration, when the data for doing so was available, and an alternate estimator to reduce bias. Those modifications have resulted in an improved and robust study, where we estimate an absolute abundance of 118 million age-2+ (CV 15%) Red Snapper in the U.S. Gulf of Mexico.

The details regarding the reanalysis and revisions can be found summarized in a bulleted list below as well as rigorously described in the final version of the report that can be found at www.snappercount.org. Key members of our leadership team are available to update the Gulf of Mexico Fishery Management Council's SSC at a future meeting. Please feel free to contact me for any comments or questions. I can be reached at greg.stunz@tamucc.edu by email or phone: 361-825-3254.

Sincerely,

Dr. Gregory W. Stunz
Endowed Chair for Fisheries and Ocean Health
Professor of Marine Biology

The following is a detailed list of the major modifications to the report entitled, Estimating the Absolute Abundance of Age-2+ Red Snapper (*Lutjanus campechanus*) in the U.S. Gulf of Mexico, in response to the external peer-review process:

A major suggestion from each of the three external reviewers was a recommendation that there were opportunities to capture more of the variability than what was performed during the original analyses as well as reconsider various design components and re-evaluate estimators. Estimates were performed by two independent groups on the same data to provide cross validation. While the approaches, post-stratification, and application of various statistical models differed and were not stipulated a priori, these separate analyses converged with very similar estimates. For both of these analyses, we have captured as much uncertainty and additional variability as possible as well as made the recommended modifications to the calculation of the abundance estimates. This reanalysis resulted in addressing recommended changes such as removal of the original Random Forest Model, where the review team had substantial concern.

Specifically, estimates of age-2+ Red Snapper abundance are now produced by region, habitat type, and depth. In all cases, population estimates were derived by expanded mean densities, with means and variances calculated assuming simple random sampling at the lowest strata level and assuming no error in the individual sample site estimates. Means and variances at higher levels of aggregation were calculated following stratified sampling methods. The Uncharacterized Bottom (UBC) was stratified by state (TX, LA, AL/MS, FL) and depth (10-40 m, 41-100 m, 101-160 m). The FL strata was further subdivided into 3 regions (northwest, mid, south). The resulting 18 strata were used to determine the weights for the stratified estimates of mean density. For some locations (TX, LA, AL/MS) the areas of well-known large features of hardbottom were removed from the UCB areal coverage estimate. To estimate total population size for UCB and uncertainty for each stratum collected from a simple random sample, observed numbers of Red Snapper per $100m^2$ were treated as simple random samples and population estimates were calculated as the mean density times the number of $100m^2$ sampling units in each stratum. Mean density estimates were treated differently depending on the region and sampling method. Where hardbottom habitat was mapped in detail, population estimates were made for the mapped area by region. Population estimates were also made for artificial structures and the subcategory of artificial structure pipelines. Simple random sampling of total fish counts were converted to Red Snapper numbers from site specific estimates of the proportion of Red Snapper as seen using various visual methods (ROV or TCA). Total population estimates were calculated from mean numbers per structure expanded by the assumed known number of structures for each depth strata. The overall population estimate was derived by summing over the individual categories. Estimated densities by region, habitat type, strata, and estimators describing specific sampling information are presented in detail in the report. Due to the uniqueness of the artificial reef complexes in AL/MS, abundance estimates and their standard errors were calculated directly by the PI's for that region using a slightly different approach (see section analysis sections for AL/MS in report). The estimation teams incorporated their estimates into the Gulf-wide total Red Snapper estimate and its variance, using the methods we describe in detail in the report.

Validation Analysis:

We performed a separate independent analysis on the same data set to validate our primary estimate of absolute abundance. While the two estimation procedures used the same data, the analyses differed in some analysis choices, post-stratification methods, and the estimators used for abundance and standard error estimates. In the validation estimation procedure, a separate estimate of total Red Snapper abundance was made within each stratum and post-stratum. The estimates of total abundance were summed to achieve a Gulf-wide estimate. The individual estimates of abundance were either Mean-per-unit estimators (if sampling units were the same size or there was no size measure beyond a classification, as for artificial reefs) or Standard Ratio Estimators (if sampling units varied in size, such as varying size transects). In most strata, the number of Red Snapper reported in a transect or artificial reef were regarded as having no uncertainty, and variances were computed based on standard methodology for randomization-based estimation. In a few strata, however, the data was available to calculate an additional variance component to measure the added uncertainty of the calibration method. In these cases, standard errors to reflect this added variance are reported. Additionally, a "Conservative CV" was calculated to account for additional variability overall, regionally, and among habitat types. The details are included in the report. While the estimator approach, post-stratification, and application of statistical methods differed and were not stipulated a priori, these independent analyses produced similar estimates (i.e., within 6.0%; 7.2 million Red Snapper difference between the estimates).

Other Detailed Changes:

- The estimate of artificial reef off AL/MS was recalculated based on reviewer suggestions. See report for detailed description and modifications to analysis.

- Some SSC members commented that the density of Red Snapper on natural reef complexes seemed high compared to other studies, especially for MS/AL. To accommodate this concern, we re-examined the site-specific density estimates and did remove two data points that were much higher than other samples within that region. Although these were not "outliers" by any standard definition, they were removed in an effort to make a more conservative estimate.

- The reviewers were concerned that visibility constraints and other detectability issues were often a limitation to the study, and that variability may not have been taken into account in our CV calculation. This is an unavoidable constraint and is a natural inherent issue when sampling across the wide range of depth, habitats, and water clarity wherein Red Snapper occur. It is also a parameter that is very difficult to account for. Thus, for the validation analysis, we estimated both a CV and a "Conservative CV" that would capture some of the additional variance associated with visibility. See validation analysis in the report and Table 7 for details.

- There were discrepancies regarding the number of artificial reefs off LA due to differences in data sets reporting the number of active, removed, and reefed oil and gas platforms. These differences have been resolved to reflect 1,771 structures in LA. There are also changes to the number of artificial reefs from TX for similar reasons. Those changes are detailed in the report.

- The total estimated density of Red Snapper on pipelines was modified to reflect a linear estimate based on the current Gulf regulations for pipeline burial requirements.

- As recommended by the review team, the stratification for the pipeline abundance has been removed and is now reported as a Gulf-wide estimate.

- It was clear from the reviewer's comments and concerns that the report did not do an adequate job of explaining the random nature of our sampling and site selection. Thus, the reviewers expressed some concerned regarding what appeared to be non-random sampling for certain sampling gears (e.g., CBASS, TCAs, and others). However, and to be very clear, all sampling was in fact randomized, and our sampling methodologies have now been clarified explicitly in the text in the appropriate methods sections for each region. Specifically, to increase sampling over UCB due to the presumed high occurrence of cells containing zero fish biomass, a transect approach was used on UCB in TX and LA with towed gears sampling a large number of cells on each deployment. This is different than the approach used to sample "single cells" on each deployment conducted on UCB in FL. Given that transects sampled 30-50x more cells on each deployment, the design for towed-gear transects did not follow the individual cell randomization on UCB in FL. For towed-gear transects, distance between sampling stations was not uniform; however, the selection of random starting points for each transect was constrained (within a ~1-5 km interval) at pre-determined distances along intended vessel tracks to provide sufficient spatial coverage. This allowed for surveys of multiple depth strata on each vessel trip, and relatively linear vessel routes which were often required to conduct towed-gear deployments at multiple starting points along an inner to outer shelf track, particularly for day trips. Transect heading (N, S, E, W) were also selected at random for the starting point of each transect, and adjustments to the heading were required at times when towed-gear performance was negatively impacted by prevailing currents.

- Similarly, the reviewers also pointed out that in some cases it was difficult to determine how the stratification was used in the analyses. How our sampling and stratification was performed is now explicitly detailed in the text modification in the analysis methods.

- There was some concern with from the SSC regarding sampling effort of UCB in relation to the large number of fish we discovered using this habitat type. Moreover, this concern further justifies the transect approach used for both towed gears to generate more sampling units on UCB by both the TARAS and CBASS teams. An assumption going into this survey was that zero values in cells on UCB were likely going to be high, which was an accurate assumption. As a result, there was concern that the 380 survey units (90 x 90 m cell) allocated by design team for TX may not be sufficient to capture natural variability of red snapper on UCB across TX shelf. If 90% of the survey cells had zero Red Snapper (no fish biomass on EK-80), the abundance estimates from only 10% (n = 38) of the cells with fish biomass will have a disproportionate impact on the expansion of these abundance estimates across the shelf. However, our transects methods provided ~3,500 survey units on

UCB in TX alone, which is almost an order of magnitude increase in the number of survey units provided in the original power analyses from Phase I of the experimental design. It is our opinion that the increased number of cells surveyed on UCB were more than adequate, and using the transect approach allowed us to survey more area, which in turn better captured natural variability. As a result, uncertainty surrounding the scaled-up abundance estimates across all UCB on the entire TX shelf was certainly reduced by the number of cells surveyed.

- The review team had some questions and requested clarity in the text regarding how imputations were done for some of the regions. Those details are now included in the text for the relevant sections where imputations occurred.

- The reviewers were concerned that not all the variability present in the estimates were reflected in the standard errors, since the Red Snapper abundance reported for sampling units were, in most cases, based on a calibration method. Thus, there was concern that the 11% CV reported was an underestimate. The reanalysis shows this not to be the case with only moderate increase in CV. In the re-analysis, we included this additional variance in the standard error estimates for some post-strata. When the calibrated abundance reported or the estimator itself was actually a product of two random variables and data were available for estimating the variance of both (as for Artificial Reefs in AL/MS and UCB in Texas), a standard error reflecting this added uncertainty was calculated, using the well-known method of Goodman (1962). The additional variability did increase the standard error of the aggregated estimate, but only moderately. For example, the Texas UCB abundance estimate showed about a 9% increase in its standard error when the extra component of variance was incorporated. These standard error estimation procedures are described in the analytical methods section of the report and reflected in the final estimates.

- There were some discrepancies in sample size due to various aspects such as what was sampled, and what was useable data for analysis (e.g., gear malfunction, weather, etc.), post-stratifications, sampling nuances, etc. Those details were not as clearly and explicitly reported as they could have been. Those have now been updated to consistently reflect the sample size collected and sites that were used in the analyses throughout the report. These are detailed throughout the report, see Tables 5 and 7 for summarized details.

- The external review team was concerned and asked the team to verify that UCB sites sampled with towed gear that might occasionally encounter known mapped natural reef or perhaps be near mapped pipelines (i.e., unknown features were considered to be a part of UCB but now known). While these factors were controlled for during our initial sampling site locations; nevertheless, locations of these data were re-plotted against known features. While the sampling design specifically avoided these areas, there were a small a number of samples that could be considered in close enough proximity natural feature or pipelines to have an influence, although unlikely. For the rare instances where this concern existed, and there potentially could have been influence from the structure, those samples were excluded from the analysis. Thus, to be as cautious and conservative as possible, those samples have been removed from the UCB for analysis.

- The extent of artificial reef number and natural bottom for MS/AL has been verified to the best of the PI's ability given the relative paucity of high-resolution mapping of natural bottom features in the area (a limitation we discussed throughout the Gulf in our Phase I report). Some questions were raised concerning estimating the number of artificial reefs off MS (AL had a systematic survey of their reefs). We restricted the number of reefs in MS to just the publicly known sites, although there are likely numerous unpublished artificial reefs in MS coastal waters that would certainly increase the estimate. Nevertheless, to be as conservative as possible, we did not consider these additional potential reefs for the analysis.

- Several of the key summary tables (e.g., Tables 5 and 7) have been modified to include Total Area/Structures, Number of Samples, and Area Sampled as requested by the external review team.

- Additional references and associated text were added throughout the document as recommended by the external review team as well as addressing minor typographical errors.