
THE GREAT
RED
SNAPPER
COUNT
Estimating the Absolute Abundance of Age-2+
Red Snapper in the U.S. Gulf of Mexico.
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I. Executive Summary

Rationale

The primary goal of this initiative was to estimate the absolute abundance of age-2+ Red Snapper (*Lutjanus campechanus*) in the U.S. waters of the Gulf of Mexico (Gulf). The fishery supported by this species is of iconic stature and supports one of the more economically valuable finfish fisheries in the region. Funding was made available by the U.S. Congress and administered through the Mississippi-Alabama Sea Grant Consortium to produce a Red Snapper population estimate independent of the federal stock assessment via a systematic Gulf-wide sampling plan at an unprecedented regional scope and level of funding. Management decisions by the Gulf of Mexico Fishery Management Council based on previous SEDAR (Southeast, Data, Assessment, and Review) stock assessments for Red Snapper have been contentious, and there is concern that the current assessment framework, given the nature of the data involved, is not providing an accurate estimate of abundance. Results of this study provide an independent assessment of Red Snapper stock size via fishery-independent surveys conducted throughout the U.S. Gulf. This is an exceptionally rare opportunity in fisheries science allowing for studies of absolute abundance of this scope and geographic coverage. Moreover, study findings offer a unique opportunity for other approaches to be integrated into the assessment framework. Thus, the ***primary rationale*** for funding was that a robust estimate of absolute abundance will increase our scientific understanding of the population dynamics for Red Snapper across its range and distribution. Science is a building process, and the independent estimate of abundance derived from this research is not a replacement or in contention with the official SEDAR Red Snapper Stock Assessment. It will supplement and enhance ongoing analyses by allowing for validation, calibration, and further refinement of those models, given absolute abundance has now been estimated independently from the assessment model.

The product reported here is the result of many planning meetings led by a formal Steering Committee. This committee facilitated execution of the study over two separate Requests for Proposals (RFPs). This document represents a report and abundance estimation from an in-depth multiphase design, including project design, implementation, analyses, and interpretation. Briefly, the steering committee convened numerous meetings and hosted several workshops for leadership teams, scientific investigators, review scientists, statisticians, and other constituents. These meetings resulted in an RFP for Phase I (see Appendix E). This phase dedicated $600,000 to fund six research teams to develop and present independent designs that would accomplish the specified goals and objectives to ultimately generate an absolute abundance estimate for Red Snapper. In a unique and valuable approach, the steering committee then coalesced the most appropriate and desirable aspects from these proposals into an overall prescriptive design to generate an independent abundance estimate in a second RFP. The Phase II RFP (Appendix E) explicitly detailed the scope, goals, and objectives of the study including general methodologies of how a successful team should carry out the abundance assessment including: general statistical analyses, target coefficient of variation (CV), geographic scope, habitat types to assess, depth ranges, and a comprehensive stakeholder engagement component.

Also required was an incorporation of an extensive fish tagging component. Recognizing that a single sampling method was not capable of providing Red Snapper abundance estimates in each habitat type across the entirety of the Gulf region, the RFP recommended and encouraged the use of multiple sampling methodologies that would most likely succeed. In addition, teams were charged with developing new advanced technological methodologies appropriate to meet the goals of the study that would otherwise have not been available. Studies that involved genetic-based methodologies were prohibited; however, collection and archiving of samples for future analyses were encouraged and accomplished. Additionally, the Steering Committee recognized that current bottom habitat mapping was not sufficiently comprehensive to represent the coverage of all Red Snapper habitat in the U.S. Gulf. While teams were encouraged to synthesize existing imagery on habitat distribution, the RFP specifically excluded any additional direct mapping activities. Thus, teams were to use what habitat characterization was available to generate the abundance estimate. For areas that were unmapped/unclassified, yet hypothesized to support a large abundance of Red Snapper, the RFP specified these areas fall into a 'catch-all' category of Uncharacterized Bottom (UCB). This process culminated into an intensive written and live three-day peer-review administered by the Gulf of Mexico Fishery Management Council. The process of driven by a team of expert independent external reviews, Drs. Steve Cadrin, Mary Christman, and David Eggleston, including review by members of the Council's Scientific and Statistical Committee. This report integrates their comments, suggestions, and analytical recommendations.

Sampling Techniques and Design

A major challenge facing this scientific assessment was developing a robust design and relatively unbiased sampling methods that could be applied among the many habitat types and regions across the U.S. Gulf. Both the Steering Committee and our team concluded there was no single method that could efficiently and accurately sample the diversity of habitats given the heterogeneity in geology, habitat types, and water clarity found across the Gulf shelf. Thus, different sampling methods were developed and used in each region to estimate Red Snapper abundance. A stratified random sampling design was developed to generate abundance by region, habitat type, and depth. In this design, the Gulf was separated into eco-regions that closely mirrored state jurisdictional boundaries. Within each region, zones were defined by depth (approximately 10-40m, 40-100m, 100-160m) and habitat type: artificial reefs, natural hard bottom, and uncharacterized bottom (UCB). A suite of methods was deployed to obtain local abundance estimates to accommodate the heterogeneity on the U.S. Gulf shelf, and to fulfill the project mandate of developing and advancing sampling technologies. A preferred method of determining species abundance is through visual means; however, the primary constraint on this technique was water clarity and fish detectability. The visibility limitations resulted in visual methods being primarily used in the east, where visibility was high. In contrast, hydroacoustic methods were primarily used in the west, where water clarity was poor. Remotely operated vehicle (ROV) visual count surveys were used to evaluate densities on artificial and natural substrates in Florida waters. A series of ROV surveys were also used to generate species composition in other regions when visibility allowed. Within Mississippi and Alabama waters, depletion surveys were the primary method used, and in the western Gulf, ROV/Towed camera

arrays (TCA) and hydroacoustics were the methods used to generate estimates. Along pipelines and the vast expanses of UCB, a combination of acoustic and visual approaches was used to efficiently and extensively cover these habitat types. A series of behavioral experiments were conducted in Florida to test whether Red Snapper were attracted to or repelled by any of the mobile sampling gears used among Gulf regions. Finally, a mark-and-recapture study was conducted with high reward tags to provide regional estimates of exploitation and fishing effort. This tagging initiative used fisher participation and engagement in the scientific data collection process and relied exclusively on these stakeholders for the recapture of tagged fish.

Abundance Estimates

Estimates of age-2+ Red Snapper abundance were produced by region, habitat type, and depth. Where appropriate, population estimates for artificial reefs were made for various categories representing the diversity of artificial structures. Overall, we estimated an absolute abundance of 118 million age-2+ (CV 15%) Red Snapper across the continental shelf of the U.S. Gulf (Figure 1, Table 1) during late 2019. In general (see detailed analytical methods), population estimates were derived by expanded mean densities, with means and variances calculated assuming simple random sampling at the lowest strata. Where density estimates were derived from acoustic counts of total fish corrected by a region-specific proportion of Red Snapper, the uncertainty in this average proportion was incorporated into the estimated variance. Means and variances at higher levels of aggregation (region, total) were calculated following stratified sampling methods. Estimates were performed by two independent groups on the same data set to provide validation from different estimation approaches. While the approaches, post-stratification, and application of statistical models differed and were not stipulated *a priori*, these independent analyses produced similar estimates (i.e., within 6.0%; 7.2 million Red Snapper difference from each estimate). While large numbers of fish occurred over well-known habitat features such as artificial reefs and natural hard bottom, a major finding of this study showed that UCB habitat harbored the majority of Red Snapper.

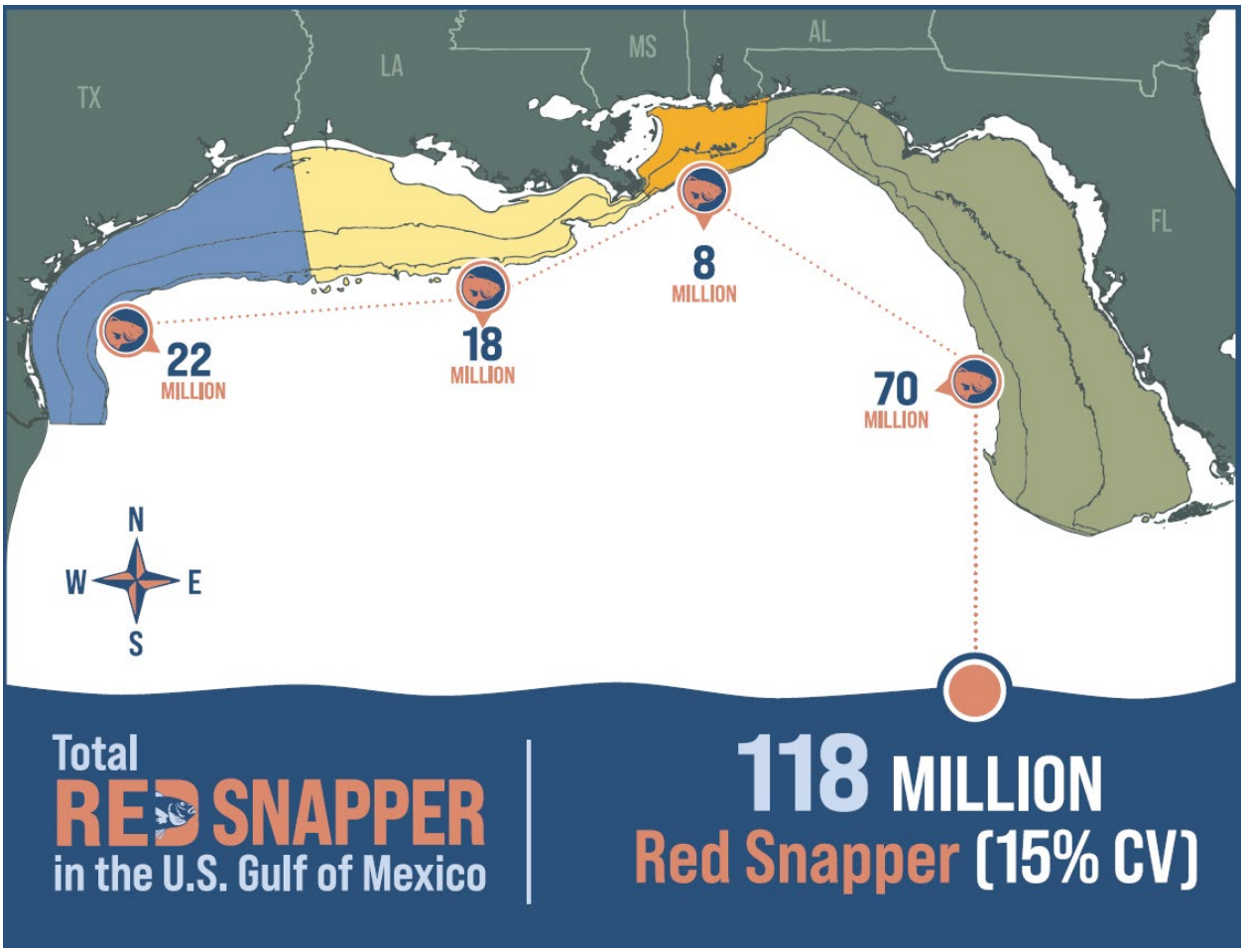

Figure 1. Overall estimate of the absolute abundance of age-2+ Red Snapper by each eco-region/state across the U.S. Gulf of Mexico.

Table 1. Estimate of age-2+ Red Snapper absolute abundance rounded to millions of fish for each state and each of the three main habitat types: Natural hard bottom, Artificial Reefs, and Uncharacterized

State /Region	Habitat Type	Estimated Abundance
Texas	Natural	7,000,000
	Artificial	<1,000,000
	Uncharacterized Bottom	14,000,000
	State Total	**22,000,000**
Louisiana	Natural	4,000,000
	Artificial	4,000,000
	Uncharacterized Bottom	10,000,000
	State Total	**18,000,000**
Mississippi & Alabama	Natural	4,000,000
	Artificial	1,000,000
	Uncharacterized Bottom	3,000,000
	State Total	**8,000,000**
Florida	Natural & Uncharacterized Bottom	70,000,000
	Artificial	<1,000,000
	State Total	**70,000,000**

Total RED SNAPPER in the U.S. Gulf of Mexico: 118 MILLION (15% CV)

Project Impacts

The primary outcome of this study was the independent abundance estimate of age-2+ Red Snapper in the Gulf by habitat type including artificial reefs, natural hard bottom, and UCB. This was a large-scale survey using well-established and novel sampling approaches that have been integrated into a larger modeling framework and applied over an unprecedented geographic area, both in size, complexity, and in new habitat types (e.g., UCB) that were previously unassessed. This study provides a robust population estimate and can be further refined as additional spatially explicit habitat mapping becomes available. The scientific approaches to surveying a widespread species occurring in diverse habitats, such as Red Snapper, were advanced by the development, implementation, and evaluation of the gear developed for this study, and that knowledge can be carried to future similar studies. The potential management implications of a higher abundance estimate of Red Snapper need to be carefully considered by policymakers/managers and are beyond the scope of this report. Already, there has been much discussion of how to appropriately integrate the sampling methodologies used in this study with the traditional fishery-independent methods used for stock assessments. This study may help refine population parameters estimated during the Southeast Data Assessment and Review (SEDAR) process and suggest potential strategies for addressing some of the data gaps inherent in the assessment by constructively challenging assumptions made in the current Red Snapper Stock Synthesis assessment model. Thus, the stock synthesis model, and perhaps others, can be calibrated to provide more accurate estimates of stock status.

Stakeholder Engagement

Stakeholder engagement was a major element of this study. The partnerships built throughout this project have been valuable for informing the general public regarding ongoing research in their community, and in many cases, creating a vested interest in the scientific understanding and conservation of our natural resources. Several design components from this project naturally facilitated an RFP-requirement for meaningful participation from recreational anglers, commercial fishermen, and other stakeholders. This component included a high-reward tagging study that was performed regionally throughout the Gulf. While scientific tagging during the initial fishing effort was necessary, recapture of the fish occurred broadly across the entire Gulf by anglers from all fishing sectors. The heavily incentivized reporting ($250 - $500 reward) of recaptured fish proved highly successful and was very popular among anglers. The return rate of over 30% eclipsed expectations. While not specifically tested in this study, these data gave key insights to high fishery exploitation over artificial reefs. The documented return rate also shows promise for use of descender devices to reduce discard mortality that should be further investigated. Captains associated with this project have expressed high satisfaction with the partnerships built during this project and conveyed their desire to remain involved in future research endeavors. Comprehensive awareness campaigns developed for the tagging study and other aspects in the abundance estimation also offered the opportunity to engage the general and angling public about this study, and this involvement allowed citizens and regional consortia to provide key support for this project. Certainly, a major benefit from this involvement was the

fishing community remained engaged in the study, recognized the value of and need for advancing science, and remained vested in a sustainable fishery.

Key Takeaways

- This study produced an estimate of 118 million (CV 15%) age-2+ Red Snapper residing in the U.S. Gulf of Mexico through 2019.

- A large percentage of Red Snapper occurred over the uncharacterized bottom habitat type, which may represent a pool of cryptic biomass not previously accounted for in Red Snapper stock assessments. A high abundance of Red Snapper occurring over these areas that are largely unexploited by the fishery may also explain the weak stock-recruit relationship consistently observed in this fishery.

- The tagging results indicate:

    - an astonishing 30% return rate of tagged fish.
    - high fishing exploitation generally occurs over habitat with the highest densities of Red Snapper (i.e., artificial reefs).
    - high angler 'buy-in' and engagement with this type of study.
    - that use of descending devices was an effective release strategy.

- This study builds on our scientific knowledge base and improves our understanding of Red Snapper abundance in a non-contentious and constructive approach to federal assessments. This absolute abundance estimate will bolster future assessments and afford other stock evaluation and management options.

- Given new effort recalibrations are underway for Red Snapper, incorporation of these newly discovered fish occurring over UCB, and understanding exploitation patterns of anglers may lead the Red Snapper stock assessment to converge with similar abundance estimates. Moreover, had this information been available for previous stock assessments, those abundance estimates likely would have been higher.

- Stakeholder engagement efforts were successful; approximately 60% of anglers surveyed were familiar with the Great Red Snapper Count. Notably, awareness of the GRSC was associated with up to three times higher satisfaction with fisheries management (Scyphers et al. *In Press*).

- While the survey methods used in the study represent a rigorous application of the best technology available, the specific results of these surveys needed to be extrapolated, since it would be impossible to directly survey all areas. The uncertainty surrounding those extrapolations are linked to the resolution of our habitat maps. We encourage, further mapping, especially of the UCB, to decrease uncertainty in future studies.

- This report is just the beginning of future assessment meetings and activities with managing agencies, Scientific and Statistical Committees, the NOAA Southeast Fisheries Science Center, and the Gulf of Mexico Fishery Management Council. These activities will facilitate direct incorporation of these data into the management process.

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Note: See Appendix A for detailed list of management structure and descriptions of roles and responsibilities for each investigator .