



SEDAR

Southeast Data, Assessment, and Review

GREATER AMBERJACK COUNT

Review Workshop Report

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SEDAR

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*On page 9, “Gulf of Mexico Fishery Management Council” was updated to “Gulf Fishery Management Council”

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1 INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The Greater Amberjack Count Review Workshop was held in Tampa, FL

March 24-27, 2026.

1.2 TERMS OF REFERENCE

1. STUDY DESIGN AND SAMPLING APPROACHES

Evaluate the study design used for developing an estimate of absolute abundance by habitat type, depth, region, and size/age. Including:

- Sampling approaches
 - Describe rationale for spatiotemporal sampling within each strata and region
 - Evaluate the assumptions inherent to the design.
 - Describe any limitations of each gear type in sampling each habitat type, depth, and region, and if and how they were addressed. Include whether there were effects on the selectivity, detectability or availability to the gear and clearly identify assumptions about catchability.
 - Detail how seasonality of distribution and movement might affect the estimates as the sampling only occurred in one season and the species is quite seasonal in its distribution.
 - Detail how species identification was accomplished with each gear type and how uncertainty in this affects overall estimates
- Calibration
 - Address whether and how the different sampling techniques are calibrated to each other to generate the estimate of abundance. Include whether the calibrations are included appropriately in the calculations of variance.
 - Detail the quantitative method(s) used to calculate catchability/detectability for each gear type as well as the variance and assumptions of the method(s).

2. STATISTICS AND DATA ANALYSIS

- Abundance Calculations
 - Address whether and how the different sampling techniques are calibrated to each other to generate an estimate of absolute abundance. Include whether the calibrations are included appropriately in the calculations of variance and whether it would apply to congeners.
 - Describe how the precision of species classifications are calculated from hydroacoustic data? How is this sampling error included/accounted for?
 - Describe how estimates were weighted by habitat type and how weightings were consistent for each region.
- Evaluate the statistical methods used to analyze the data, and to construct the abundance estimate

and its variance.

- Does the project provide abundance estimates and associated variances by length, region, and state, if applicable?
- How was the uncertainty within each habitat, region, depth and calibration included in the overall estimate of variance?
- Sample size and variance seem sufficient. Is the statistical variance appropriate for finer scale habitat-specific or regional estimates?
- Are imputations made for unsampled regions appropriate, and what are the potential implications of these imputations?

3. RESULTS

- Total Estimate and Variance
 - Detail whether the estimate and its variance should be considered consistent with input data and population biological characteristics, and useful as an estimate of abundance of age 1+ greater amberjack.
 - Does the estimated CV adequately account for known sources of uncertainty in sampling and detection rate.
 - Assumptions inherent to the methods:
 - What assumptions are made, and is each assumption appropriate given study design considerations?
 - Does the calibration and/or standardization address the magnitude and directionality of key assumptions.
- Regional/Habitat-specific/age specific results
 - Are the spatial extents of abundance estimates consistent with management boundaries for this species? If needed, can abundances be re-calculated to conform to these spatial boundaries?
 - Are size class specific estimates of abundance available and reliable?
 - Can the results be used to create spatial temporal maps of the abundance and distribution?
- Tagging and auxiliary research priorities
 - Should tagging data be considered and more formally evaluated for understanding fishing and natural mortality, migration and connectivity e.g. connections between habitat types and regions.
 - What role did the auxiliary information (e.g. eDNA) provide and was it used for maximum advantage?

4. RECOMMENDATIONS FOR FUTURE USE (for CIE reviewers)

- Describe the availability and gear source of any other biological data (such as length, age or other biological information) or other life history data (e.g. tagging, stock composition, etc) from these methods that may be useful for stock assessment.
- Does the study provide insights into spatial partitioning or stock structure for future stock assessments?
- Can you provide insights as to how these results can be best used in formal stock assessments or to provide management advice?
- How does the variability and uncertainty compare to the current stock assessment.

1.3 LIST OF PARTICIPANTS

Review Panel

Luiz Barbieri (Chair).....	Gulf SSC/ FWC
David Chagaris.....	Gulf SSC/ UFL
Gary Melvin.....	CIE
Henrik Sparholt.....	CIE
Larry Jacobson.....	CIE
Marcel Reichert.....	South Atlantic SSC
Steve Turner.....	South Atlantic SSC
Trevor Moncrief.....	Gulf SSC/ MS DMR

Project Team

Sean Powers (Co-lead PI).....	DISL
Mark Albins (Co-lead PI).....	DISL
Eric Saillant.....	USM
Grace Chiu.....	VIMS
John Hoenig.....	VIMS
Julie Gross.....	DISL
Kevin Boswell.....	FIU
Lynne Stokes.....	SMU
Marcus Drymon (virtual).....	MS State
Matthew Catalano (virtual).....	AU
Mike Dance.....	LSU
Mischa Schultz (virtual).....	LSU
Nicole Phillips (virtual).....	USM
Savannah Swinea (virtual).....	NCSU
Steven Scyphers (virtual).....	South Alabama
Ted Switzer.....	FWC

Staff

Bernie Roy.....	GFMC Staff
Carrie Simmons.....	GFMC Staff
Chip Collier.....	SEDAR
Emily Ott.....	SAFMC Staff
Jessica Matos.....	GFMC Staff
John Froeschke.....	GFMC Staff
Lisa Hollensead.....	GFMC Staff
Ryan Rindone.....	GFMC Staff
Sarah Gardiner.....	GFMC Staff

Workshop Observers

Katie Siegfried.....	SEFSC
Steve Sempier.....	MS-AL Sea Grant
Sue Lowerre-Barbieri.....	UF

Workshop Observers via Webinar

Alena Figueroa.....	FWC
Allison White.....	NOAA

Ashford Rosenberg	Shareholders Alliance
Billy Smith	
Brian Daniels	
Chloe Ramsay	FWC
Chris Schieble	LA WLF
Chris Wang	
Christopher Bradshaw	FWC
Daniel Lippi	
Ed Walker	GFMC/ Industry
Ellen Taylor	SMU
Eric Gigli	MS DMR
Erin Pereira	FWC
Frank Helies	NOAA
Genine McClair	FWC
George Sedberry	
Hayden Staley	FWC
Jason Adriance	LA WLF
Jeff Buckel	NCSU
Joana Dias	
Joel Bickford	FWC
John Mareska	AL DCNR
Julie Lively	LSU
Julie Neer	SEDAR
Kara Wall	FWC
Kelly Samek	NOAA
Kesley Banks	GFMC/ TAMUCC
Kevin Thompson	NOAA
Landes Randall	TAMU
Lewis Naisbett-Jones	LGL
Manuel Coffill-Rivera	USA
Martha Guyas	ASA
Matt Streich	TAMUCC
Matthew Nuttall	NOAA
Michelle Masi	NOAA
Molly Stevens	SEFSC
Patrick Banks	LA WLF
Peter Mudrak	LGL
Renae Schaak	MS DMR
Scott Raborn	LGL
Sean Keenan	FWC
Skyler Sagarese	SEFSC
Tami Hildahl	
Tara Topping	TAMUCC
Troy Frady	Industry

1.4 LIST OF MATERIALS AVAILABLE TO THE REVIEW PANEL

Preliminary report provided to the review panel: Greater Amberjack Count

2 REVIEW PANEL REPORT

2.1 EXECUTIVE SUMMARY

This report summarizes the findings and recommendations of an independent peer review of the Greater Amberjack (GAJ) Count project conducted during March 24-27, 2026 in Tampa, FL. The review focused on biological questions and methodology for using camera and acoustic surveys to estimate total GAJ abundance in the South Atlantic and Gulf of America regions. However, the Review Panel expressed concerns that the report provided for review (i.e., before the review workshop) was preliminary and many parts of the sections were missing or still being worked on. The study's conceptual sampling framework for abundance estimation was based on a stratified multi-stage random sampling design. Primary sampling units (PSUs) were typically grid cells defined across the seafloor, while secondary sampling units (SSUs) were either specific structures (enumerated SSUs) or randomly selected areal units within the grid cell (areal SSUs). The study relied on several assumptions to extrapolate site-level data to regional/strata totals. First, in all regions it was assumed that the amount of habitat in mapped areas is representative of unmapped portions within the same stratum. Second, the field of view and effective sampling area (ESA) was assumed to be constant for the camera gears, because this could not be determined precisely for each sample. Third, it was assumed that the ratio of GAJ to other acoustically indistinguishable "large-bodied" fish observed on video cameras could be used as a valid "deflation factor" to convert acoustic density measurements into GAJ counts, even though the ratios were only available at ¼ of the acoustically sampled sites. Telemetry data showed that GAJ movement peaks during winter and spring, coinciding with spawning in both regions. Gulf fish move short distances to natural reefs, while South Atlantic fish undergo lengthy migrations from North Carolina to the Florida Keys (although no return trips were detected). In the Gulf, the exchange between regions and across state lines is low (<1%), and the Review Panel agreed that asynchronous regional surveys are unlikely to "double count" the same fish. The Review Panel felt that propagation of uncertainty and lack of proper sampling gear calibration were important limitations of this study. Consequently, the final coefficients of variation (CVs) provided for the abundance estimates were not considered reliable and neither the camera nor the acoustic gear were found to be capable of producing final GAJ abundance estimates and standard errors for either region.

The evaluation of the absolute abundance estimates and associated variances derived from the design-based framework reveals a system of high technical sophistication but significant operational limitations. While the methodology provides a fishery-independent estimate of age 1+ GAJ, its utility is currently constrained by regional data gaps and the challenges of propagating variance across disconnected analytical phases. Given the variety of issues identified during this review the Review Panel feels strongly that results of this study should not be used in formal stock assessment or to provide management advice.

2.2 INTRODUCTION

An independent peer review of the Greater Amberjack Count project was conducted during an in-person Review Workshop on March 24-27, 2026, at the Gulf Fishery Management Council Office in Tampa, FL. The review focused on biological questions and methodology for using camera and acoustic surveys to estimate total Greater Amberjack (GAJ) abundance in large areas broken into smaller survey areas, each covered by either a camera survey or an acoustic survey, or both. In most cases the camera study was part of an existing program with sampling or analytical extensions to estimate total rather than relative abundance.

The review process followed Terms of Reference (TORs, see page 3 above) and the review report structure generally follows the TORs. The Review Panel consisted of Drs. Luiz Barbieri (Chair), Marcel Reichert and Steve Turner (South Atlantic Fishery Management Council's Scientific and Statistical Committee), David Chagaris and Trevor Moncrief (Gulf Fishery Management Council), Larry Jacobson (Center for Independent Experts, CIE), Gary Melvin (CIE), and Henrik Sparholt (CIE). The Review Panel was assisted by Southeast Data, Assessment, and Review (SEDAR) staff Emily Ott, and various South Atlantic Fishery Management Council (SAFMC) and Gulf Fishery Management Council (GMFC) staff. Prior to the review workshop the Review Panel was provided with a preliminary report, with the expectation that a revised and updated report would be available *after* this review. During the review, the Greater Amberjack Count team (led by the PI's, Drs. Sean Powers and Mark Albins) provided 15 presentations supporting and/or updating information provided in the preliminary report submitted for review.

The Review Panel expressed concerns that the report provided before the review workshop was preliminary and many parts of the sections were missing or still being worked on. Estimates for some regions were still being produced during the review workshop and presented for the first time to both the panel and the project team. This is important because it reduces Panel's ability to review the report and make presentations. Presentations were often updates of information in the preliminary report that contained a significant amount of new or corrected information making it difficult for the Review Panel to thoroughly review the various project components. Further, there appeared to be a disconnect between the project team and the Review Panel on the intent of the review. The panel structured its review on the estimates of abundance, as dictated by the TORs. The project team had expected the review to focus on the entire project, including sub-projects not related to abundance estimation or listed in the TORs. The effect of this disconnect was that a substantial amount of time of the review workshop was spent on project components not particularly relevant to the TORs.

Despite these problems, the Review Panel appreciated the very collegial nature of the review deliberations and the positive response of the Greater Amberjack Count project team to the Review Panel's comments, questions, and requests for additional information. The Review Panel acknowledged the Greater Amberjack Count project team for the incredible amount of work, the complexity of the project, and the various presentations provided during the review workshop. The Review Panel also thanks SEDAR, the Mississippi-Alabama Sea Grant Consortium, as well as SAFMC and GMFC staff for their invaluable support during the review process.

2.3 REVIEW PANEL SUMMARY REPORT

The purpose of the review was to evaluate work conducted by the Greater Amberjack Count project. There were several opportunities for the public to provide comments, but no public comment was provided prior or during the review, either in person or in writing.

The Review Panel discussions and deliberations are summarized below for each of the TORs.

1. *STUDY DESIGN AND SAMPLING APPROACHES*

Evaluate the study design used for developing an estimate of absolute abundance by habitat type, depth, region, and size/age.

A conceptual stratified multi-stage random sampling design served as the general framework for the Greater Amberjack (GAJ) abundance estimation. Primary sampling units (PSUs) were typically grid cells defined across the seafloor, while secondary sampling units (SSUs) were either specific structures (enumerated SSUs) or randomly selected areal units within the grid cell (areal SSUs). The two-stage design-based approach for camera data used counts at sampling locations (expressed as density = numbers per effective area viewed) which were averaged within strata. Strata means were then weighted and used to compute means for larger regions or stocks as densities (number per area). Total abundance was estimated directly from camera data by multiplying density times the area of the larger regions.

However, implementation details and adherence to this design varied greatly by region to accommodate existing surveys and habitat mapping limitations. Over-stratified sampling is a general problem in fish surveys, and the Review Panel felt this was also the case here. Often strata had to be skipped due to weather or logistic reasons and ways of handling missing sampling were difficult to ascertain.

Sampling approaches

Describe rationale for spatiotemporal sampling within each strata and region

The study area was partitioned into six primary subregions: Texas, Louisiana, Mississippi/Alabama, West Florida, Eastern Florida/Georgia, and South/North Carolina. Sampling was stratified by habitat type (natural reefs, artificial reefs, oil platforms, wrecks, and uncharacterized bottom) and depth (typically 20m to 150m). It was the Review Panel's understanding that this sub-regional partitioning was mostly based on the location of sub-regional surveys and contributors to the project. The habitat and depth strata were partially defined by the original RFP for this project, likely based on known differences in density and sampling approaches from previous studies (i.e. the red snapper count). Gulf surveys were primarily conducted from May to September to leverage better weather and visibility. In the Atlantic, sampling was concentrated in summer months when seasonal migration magnitudes are lower, reducing the risk of biomass shifts confounding the estimates. Grid cells were selected at random within each strata (PSUs), and sites were selected at random within a grid cell (SSUs) and assigned weights based on their probability of selection (i.e., a design-based approach as explained above).

Evaluate the assumptions inherent to the design.

The study relied on several assumptions to extrapolate site-level data to regional/strata totals. First, in all regions it was assumed that the amount of habitat in mapped areas is representative of unmapped portions within the same stratum. Second, the field of view and effective sampling area (ESA) was assumed to be constant for the camera gears, because this could not be determined precisely for each sample. Third, it was assumed that the ratio of GAJ to other acoustically indistinguishable "large-bodied" fish observed on video cameras could be used as a valid "deflation factor" to convert acoustic density measurements into GAJ counts, even though the ratios were only available at ¼ of the acoustically sampled sites. Lastly, the

use of MaxN (the maximum number of fish in a single camera frame) assumes a conservative but consistent minimum estimate of abundance that prevents double-counting of highly mobile individuals but may have generated a negative bias in fish counts. TotalCounts (count of large bodied fish in acoustic or spherical camera samples assumed no double-counting occurred, even though GAJ are gregarious, fast moving and known to circle cameras).

Describe any limitations of each gear type in sampling each habitat type, depth, and region, and if and how they were addressed. Include whether there were effects on the selectivity, detectability or availability to the gear and clearly identify assumptions about catchability.

Neither the camera nor the acoustic gear were capable of producing final GAJ abundance estimates and standard errors in any region. Optical gears are fundamentally constrained by water visibility, which is particularly problematic in the Western Gulf. The ESA by camera gears was unknown and likely highly variable across sites due to attraction and nearby habitat availability, thus requiring critical assumptions to convert counts to density. An attempt was made to approximate ESA based on other information and intuition of the regional PIs and sensitivity analyses were done around the estimates Field Of View (FOV). Estimates were apparently available from the vertical drop survey because a mean and max were assumed for calculating the density. However, this information was not presented and, therefore, the Review Panel was unable to evaluate the assumption of a constant FOV. Understanding how FOV estimates varied across sites would have helped alleviate Review Panel concerns about density scaling (i.e. is the mean appropriate?) and the assumed ESA, which is the most critical value for scaling the counts to density. In addition, the stationary cameras (S-BRUV and traps) are also restricted by their inability to sample the full water column, potentially missing individuals swimming at or above higher relief structures (though this may have been less of an issue on natural hardbottom).

While MaxN serves as a good metric for tracking relative abundance, it may not scale to true density and very likely underestimate site abundance of GAJ. On the other hand, TotalCount from the vertical platform drops might suffer from double counting, especially for GAJ that are known to circle camera gear. The PIs assured the Review Panel that double counting did not occur in the western Gulf vertical transects, yet no evidence was provided to support this critical assumption. It would have helped to see how TotalCount relates to MaxN, or video from a second camera that observes the transect drop to evaluate potential for double counting.

There is also a size-selectivity bias, as identifying *Seriola* species on video is notoriously difficult especially at small sizes, leading to the underrepresentation of Age-0 and Age-1 individuals. Such errors might affect acoustic estimates because camera data were used to prorate raw acoustic data into species-specific components and in developing calibration models. Genetic analysis showed that experts who inspect sampled fish physically can misidentify GAJ, particularly when small. None of the information presented suggested that that misidentification had a major effect on results, but it wasn't clear whether this should be examined in more detail. In any case, it is not practical to estimate recent recruitment using camera or acoustic gear. It would be useful to clearly define the sizes and ages at which cameras and acoustic gear are able to sample GAJ in a representative way.

Hydroacoustics provided high-resolution volumetric density data but lacked taxonomic specificity, as it was not possible to distinguish between GAJ and other "large-bodied" species. Importantly, camera-derived species ratios (used to adjust the acoustic counts) were only available on 25% of the sites. That means 75% of the acoustic data do not actually provide GAJ count data and the Review Panel recommends that it should be excluded from the analysis. Pooled ratios were used to generate the estimates, but no analysis was presented (such as a fish community composition) to support the assumption that species compositions are transferable across large spatial domains. Furthermore, acoustic systems possess inherent "dead zones" (shadow zones) where targets cannot be resolved. Complex vertical structures, such as oil platforms, create interference and multipath reflections, necessitating specialized transect designs.

Detail how seasonality of distribution and movement might affect the estimates as the sampling only occurred in one season and the species is quite seasonal in its distribution.

Telemetry data showed that movement peaks during winter and spring, coinciding with spawning in all regions. Gulf fish move short distances to natural reefs, while Atlantic fish undergo lengthy migrations from North Carolina to the Florida Keys (but no return trips were detected). In the Gulf, the exchange between regions and across state lines is low (<1%), and the Review Panel agreed that asynchronous regional surveys are unlikely to "double count" the same fish. Atlantic surveys occurred during the summer (May–October) when movement magnitude is low and no interstate movements were detected by the array. While double counting fish due to movement is possible, the Review Panel commented that it is safe to assume that the effect would be negligible on the estimates due to timing of samples and movement data presented.

Detail how species identification was accomplished with each gear type and how uncertainty in this affects overall estimates

Species identification was not possible using just acoustic data. Rather, acoustic signal strength was filtered to fish greater than 20 cm located at certain areas of the water column. Species identification in the camera gear was impacted by visibility, and small *Seriola* species are almost indistinguishable on cameras. This could result in underestimates of abundance, as small *Seriola* spp. are not included in the count of GAJ. It was reported that 2% of fish sampled by trained scientists for genetics were misidentified by trained observers who handled actual specimens.

Calibration

Address whether and how the different sampling techniques are calibrated to each other to generate the estimate of abundance. Include whether the calibrations are included appropriately in the calculations of variance.

A new calibration approach was attempted using data from the Alabama-Mississippi region. The intention was to use the acoustic data as the unifying gear type to which all camera gear could be calibrated towards. To accomplish that, an experiment was conducted and a hierarchical Bayesian calibration model was developed. However, the experiment was only conducted in the Alabama-Mississippi region in an "extremely unbalanced" design with only 21 samples over mostly artificial reef habitat, which may not be representative across the study area. In the Gulf, due to different camera types (stereo, spherical, single camera) the calibration model was used to convert to a spherical camera currency. In the South Atlantic, an *ad hoc* calibration was used to convert single camera SERFS data to spherical currency using a quantile-based approach. Acoustic densities and camera counts were related to one another using pooled or site-specific ratios of GAJ MaxN to total MaxN, as discussed above.

The project team assumed that converting all site data to a common currency (density per unit area) was equivalent to a gear calibration. However, the Review Panel found the gear calibrations to be insufficient and the conversions to a common currency to be largely either *ad hoc* or based on data/models that are not transferable across study regions.

Detail the quantitative method(s) used to calculate catchability/detectability for each gear type as well as the variance and assumptions of the method(s).

Catchability and detectability were handled through quantitative proxies and spatially explicit sampling buffers. The primary abundance metric for camera gear is MaxN (the maximum number of individuals in a single frame), which is assumed to be a conservative, non-additive minimum estimate that prevents double-counting of highly mobile individuals. In the western Gulf, TotalCount from vertical transects was used, which likely suffers from double counting. To convert site-level counts into regional densities, the project team used moderately conservative "effective sampling areas" ESAs (larger ESA = lower

density). For stationary baited cameras (S-BRUV and traps), the ESA was estimated as a circle with a radius of 108-m based on an average current velocity of 0.1 m/s and an 18-minute bait plume travel time. Virtual Positioning System (VPS) telemetry data from AL and NC showed an area of use slightly larger than this. For ROV surveys, the ESA was calculated using the 90% kernel density of fish positions during 20-minute intervals derived from acoustically tagged fish. Acoustic detectability was refined by filtering raw backscatter to remove unreliable multiple echoes, nepheloid layers, and small-bodied fishes (<20 cm TL). The study assumes acoustic targets cannot be resolved within a 0.5 m bottom offset and a 5.5 m surface offset, representing inherent gaps in availability to the gear

In all camera estimates, the ESA and FOV were assumed to be constant for each gear type and region. The Review Panel felt this presents issues, as the ESA and FOV are likely to vary across sites such that the use of a mean value introduces biases at the site and strata level. The GAJ report explicitly cautions, and the Review Panel agrees that the final coefficients of variation (CVs) are "not entirely reliable" because uncertainty from certain stages, including those associated with catchability/detection, rely upon imputed values. The Review Panel recommended further investigating this critical issue.

2. STATISTICS AND DATA ANALYSIS

Abundance calculations

Address whether and how the different sampling techniques are calibrated to each other to generate an estimate of absolute abundance. Include whether the calibrations are included appropriately in the calculations of variance and whether it would apply to congeners.

See specific notes above under "Calibration" for a more in-depth discussion of calibration among gears. However, as far as developing variance estimates, the Review Panel felt that propagation of uncertainty was a recognized limitation of this study. Consequently, the final coefficients of variation (CVs) provided for the abundance estimates were described as "not entirely reliable".

While the focus was *Seriola dumerili*, the methodology is technically applicable to congeners (*S. rivoliana*, *S. fasciata*, *S. zonata*). The species ratios used to deflate acoustic counts explicitly account for a suite of "large-bodied" fish, including these congeners. However, to maintain a conservative "worst-case scenario" for GAJ, individuals identified only to the genus level (*Seriola spp.*) were typically excluded from final absolute totals.

Describe how the precision of species classifications are calculated from hydroacoustic data? How is this sampling error included/accounted for?

The precision of classifications was managed through an echo-classification and filtering regime. Data were processed to exclude acoustic dead zones within 0.5 m of the seafloor and 5.5 m of the surface. Algorithms (e.g., SHAPES) isolated "potential *Seriola*" targets, defined as large-bodied (>20-25 cm fork length) fish that were solitary or loosely aggregated, thereby filtering out small-bodied, tightly schooled, or benthic individuals. Uncertainty in the abundance of potential *Seriola* was quantified at each site as the mean absolute difference between echo integration (Nei) and echo counting (Nec), the latter relying on an alpha-beta tracking algorithm to detect target traces. This acoustic uncertainty was integrated with the error inherent in the video-derived species ratios to produce site-level estimates.

As stated before, the Review Panel was concerned that 75% of the acoustic samples did not have species ratios at that site and therefore relied on pooled species ratios. The pooled ratio sites are not viewed as valid counts of GAJ. The Review Panel felt that this had a critical impact on the overall population estimate and additional, more conclusive evidence should be provided to demonstrate that species compositions and GAJ ratios are statistically similar within strata.

Describe how estimates were weighted by habitat type and how weightings were consistent for each region.

Abundance estimates were generated independently for specific strata and then aggregated. Enumerated Habitats (artificial Reefs/platforms) used ratio estimators (abundance per structure $\times$ total number of structures in the universe). On vertically complex platforms, abundance was scaled based on the number of structural piles. Areal habitats (natural reefs/unconsolidated bottom) used ratio estimators (mean density $\times$ known or extrapolated habitat area).

Sites within strata were weighted based on the inverse probability of selection. While appropriate statistically, proper weighting was limited by the varying quality of underlying habitat maps. While West Florida relied on 15 years of randomized mapping, the South Atlantic and other regions utilized predictive models with "tremendous uncertainty," necessitating ad hoc correction factors that likely introduced regional variability in weight reliability. The Review Panel felt that the associated uncertainty was not (fully) accounted for in the population estimates.

Evaluate the statistical methods used to analyze the data, and to construct the abundance estimate and its variance.

The statistical framework for the GAJ Count utilizes a hybrid methodological approach, integrating classical design-based estimators with complex Bayesian hierarchical modeling to reconcile multi-modal sampling data across disparate spatial scales and habitats. However, at time of the review, the Bayesian model was not ready to produce the estimates due to data only being available from MS/AL, although it provided a useful framework. All estimates provided in the report and during the review workshop were design-based estimates. Most regions utilized a stratified multi-stage random sampling design. Strata were defined by the intersection of region, habitat type (artificial, natural, uncharacterized), and depth. The Review Panel felt that in strata with enumerated secondary sampling units (SSUs), such as artificial reefs, a ratio estimator would be preferred when total structure counts are known, while a mean-per-unit (MPU) estimator should be used when they are unknown. For areal SSUs (e.g., natural hardbottom), ratio estimators extrapolate observed densities to total habitat area.

Does the project provide abundance estimates and associated variances by length, region, and state, if applicable?

GAJ are primarily found around structure (natural reefs, artificial reefs, and platforms) and very few are found outside of those areas. A large portion of the habitat in the Gulf of America and the South Atlantic has not been mapped with sufficient accuracy. Uncharacterized bottom (UCB) therefore does contain unmapped structure and at times concentrations of GAJ occur on that structure. As a result, the abundance of GAJ on uncharacterized bottom can be extremely variable and some of the estimates of total abundance on UCB were extremely/unrealistically high. Thus, preferred estimates of total abundance in both regions were not available. Extensive fine scale mapping of Gulf and South Atlantic bottom developed under randomized sampling designs will be required to produce complete estimates of absolute abundance with CVs of 0.3 or less.

Besides these technical limitations, the estimates provided in the preliminary report were incomplete or not provided. During the workshop, more estimates were provided through presentations, with some estimates seen by the project team for the first time on the last day of the workshop. However, even these were incomplete with respect to certain gear, strata, and the standard errors.

In the western Gulf, estimates were provided for all strata and converted to age using an age-length key (ALK). Estimates of abundance were available for Alabama, but not Mississippi. Acoustic estimates were unavailable for west Florida, and South Atlantic estimates were provided with high degree of uncertainty (on day 3) and possible errors in calculations that were never resolved by the project team during the workshop.

The Review Panel found that the use of a single ALK to convert lengths to ages was inappropriate, given strong differences in size compositions and subtle differences in growth among regions. In the South Atlantic, length measurement data were sparse because SERFS uses single cameras and derives lengths from trapped specimens (GAJ do not enter traps). Overall, the Review Panel concluded that reliable GAJ population estimates by sub-region and habitat could not be provided during the review.

How was the uncertainty within each habitat, region, depth and calibration included in the overall estimate of variance?

The Review Panel identified uncertainty propagation as a major limitation of the study. For the design-based abundance estimations, the propagation of uncertainty across habitat, region, depth, and calibration parameters is managed through a stratified multi-stage sampling framework utilizing Taylor series expansion (the delta method) for variance estimation. Because the sample design specifies independent selections from one stratum to another, the total abundance estimate for a region or the entire sampling universe is the sum of individual stratum-level estimates. Consequently, the overall variance is calculated as the square root of the summed estimated variances from each independent stratum. Uncertainty in uncharacterized bottom was also found to be very high, and the estimates of abundance for this habitat were excluded from the total. The variance calculations within each stratum were highly dependent on the nature of the secondary sampling units (SSUs).

Does sample size and variance seem sufficient? Is the statistical variance appropriate for finer scale habitat-specific or regional estimates?

While the method of calculation is appropriate, the resulting variances often indicate that the estimates provided were not reliable at the fine scale (individual habitat strata or small subregions) due to several factors. In the western Gulf, camera-based estimates for the UCB habitat were deemed "unreliable due to extremely high uncertainty" and were excluded from final reporting. For example, the Louisiana UCB estimate was 27.8 million fish, but the associated standard error (SE) was 27.4 million, making the estimate practically unusable for management at that scale. The project team noted that uncertainty was consistently high for habitats requiring area-based measurements, such as natural reefs. Even in west Florida, which featured the most robust sampling intensity, the "highly variable nature" of GAJ occupancy and site-specific abundance complicated the ability to produce precise fine-scale estimates. In the Alabama-Mississippi region, the sampling design often resulted in only one observation per cluster at the second or third sampling unit stages (e.g., one reef per cell or one patch per reef). Because components of variance cannot be estimated without replicates, the researchers were forced to provide "conservative" variance estimates (biased high), which limits the statistical power of habitat-specific comparisons in that region.

Data sparsity was also an issue in the South Atlantic. The report suggests that partitioning abundances by size or age is "not recommended at present" due to extremely sparse measurement data. Additionally, the lack of randomized mapping in this region introduced "tremendous uncertainty" into the underlying habitat composition used to weight the estimates.

While the design-based variances are calculated correctly according to sampling theory, they are often not appropriate for definitive fine-scale habitat-specific inference because the high coefficients of variation (CVs) reflect a lack of precision driven by the species' mobile nature and sparse distribution across the shelf. The estimates are generally more reliable when aggregated at larger regional levels (e.g., western Gulf total excluding UCB), where the summed variances result in a more stable, though still broad, confidence interval.

Are imputations made for unsampled regions appropriate, and what are the potential implications of these imputations?

Within the design-based framework, significant imputations in both densities and habitat proportions were required to address sampling gaps in the Mississippi subregion, ultimately resulting in the exclusion

of MS from the total estimate.

The imputation of GAJ ratios (MaxN / sum of MaxN for all species) for 75% of acoustically-sampled sites was found by the Review Panel to be inappropriate. The assumption of similar species compositions within and among strata where borrowing occurred was not supported by any evidence (e.g., a community analysis). By treating imputed values as fixed rather than estimates with their own variance, the final CVs for each region are unrealistically low.

3. RESULTS

Total Estimate and Variance

Detail whether the estimate and its variance should be considered consistent with input data and population biological characteristics, and useful as an estimate of abundance of age 1+ greater amberjack.

The evaluation of the absolute abundance estimates and associated variances derived from the design-based framework reveals a system of high technical sophistication but significant operational limitations. While the methodology provides a fishery-independent estimate of age 1+ GAJ, its utility is currently constrained by regional data gaps and the challenges of propagating variance across disconnected analytical phases.

Does the estimated CV adequately account for known sources of uncertainty in sampling and detection rate.

No. The estimated CVs do not fully account for all known sources of uncertainty, particularly those arising from data imputation, gear detection variability, and expansion to unknown habitats. The researchers characterize uncertainty propagation as "*ad hoc*" because the project was handled in six standalone, unconnected phases. A fully integrated model was computationally infeasible, meaning the final CVs are "not entirely reliable". In regions requiring significant imputation (e.g., Mississippi), the uncertainty associated with external data filling was "simply ignored," leading to narrow confidence intervals that likely overstate precision. While the design-based framework incorporates calibration uncertainty as a "third stage of sampling," this relies on the assumption that calibration estimators are unbiased. However, poor goodness-of-fit in some gear calibrations (e.g., $R^2=0.16$ for trap cameras) indicates a high potential for unquantified measurement error.

Assumptions inherent to the methods:

What assumptions are made, and is each assumption appropriate given study design considerations?

A more detailed discussion of the assumptions inherent to the methods applied to this study is provided under the 3rd bullet of TOR 1 above.

Does the calibration and/or standardization address the magnitude and directionality of key assumptions.

In some cases, yes. The conversion from single camera to spherical camera counts resulted in an increase in fish density, whereas the total large-bodied fish abundance was reduced by the species ratios. However, the full gear calibrations were not conducted in all regions and therefore were not considered as sufficiently completed.

Regional/Habitat-specific/age specific results

Are the spatial extents of abundance estimates consistent with management boundaries for this species? If needed, can abundances be re-calculated to conform to these spatial boundaries?

Theoretically, the regional estimates can fit within GAJ management boundaries (Gulf and South Atlantic regions) or be utilized at a finer spatial scale (subregion strata with regions). However, given the

incomplete sampling in some subregions the Review Panel feels that abundance estimates at that finer scale are likely unreliable.

Further, the preliminary report provided to the Review Panel and in various presentations at the review workshop it seemed that uncharacterized (unknown) bottom habitat was used synonymously with (known) unconsolidated bottom (UCB), and the use of this terminology does not seem to be consistent throughout the report. In some areas the habitat was known as unconsolidated (e.g., sand, mud), so the bottom habitat was known. However, none of the analyses included this unconsolidated bottom and it was not clear why. Adding a known unconsolidated bottom category to the habitats identified by this project may reduce uncertainty and provide a more realistic picture of the bottom habitat sampled.

Are size class specific estimates of abundance available and reliable?

See above. Size class estimates of abundance are reliable, except in the South Atlantic, where length measurements are lacking. Converting to ages is questionable due to the use of a single ALK.

Can the results be used to create spatial temporal maps of the abundance and distribution?

A single map could probably be developed, but not temporal maps as sampling was not conducted over time. The design-based estimates provide a static spatial "snapshot" of absolute abundance during the sampling period, while the telemetry and GAMM results provide the dynamic temporal context needed to understand how those distributions evolve throughout a calendar year. Major gaps would exist, however. No distribution map was produced by the project team.

Tagging and auxiliary research priorities

Should tagging data be considered and more formally evaluated for understanding fishing and natural mortality, migration and connectivity e.g. connections between habitat types and regions.

The analysis of conventional tag return data was determined to be inappropriate, as the estimation model did not account for movement and assumed 100% reporting. The conventional tag data should be re-analyzed using a different model to account for the unobserved states of tagged fish, rather than assuming they are all going to natural mortality.

The acoustic telemetry data provided valuable information on GAJ movement and migrations. This was one of the more complete elements of the research project.

What role did the auxiliary information (e.g. eDNA) provide and was it used for maximum advantage?

The eDNA data were not used in any other parts of the project or in the production of abundance estimates.

4. RECOMMENDATIONS FOR FUTURE USE

Describe the availability and gear source of any other biological data (such as length, age or other biological information) or other life history data (e.g. tagging, stock composition, etc.) from these methods that may be useful for stock assessment.

Other data useful for stock assessment include some otolith-based age samples, regional growth curves, length compositions, and genomic stock identification. However, the age data from this project should be combined with all age samples to produce regional growth curves, and length compositions are biased towards large fish (as small fish were unidentifiable to species). Catch curves were used to estimate natural mortality rates, but they are sensitive to the ALK.

Does the study provide insights into spatial partitioning or stock structure for future stock assessments?

Telemetry revealed that while the species is capable of long-distance movement (e.g., North Carolina to Belize), adult exchange between the Gulf and Atlantic regions is low (<1%), supporting separate

management units. Surprisingly, thousands of markers revealed very little genetic divergence between Gulf and Atlantic stocks, suggesting possible recent gene flow or historical mixing that contradicts the demographic separation observed in telemetry.

While genomic data suggests a single interconnected population, telemetry and life-history data strongly support maintaining and potentially refining current management boundaries. The lack of adult movement between the regions validate the continued use of separate management units for the Gulf and South Atlantic.

Telemetry and demographic data suggest the potential for further sub-structuring within the Gulf stock. Exchange across the Mississippi River Delta was limited, and significant differences in growth trajectories were observed between the eastern and western Gulf.

However, the development of growth curves was flawed and differences in growth among regions cannot be determined. Growth curves should be re-estimated, this time allowing the t_0 parameter to be estimated. The analysis presented by the project team fixed that parameter at 1.04, despite having size-at-age data available at age-0 fish.

Can you provide insights as to how these results can be best used in formal stock assessments or to provide management advice?

Given the variety of issues discussed in previous TORs, the Review Panel feels strongly that results of this study should not be used in formal stock assessment or to provide management advice. The abundance estimates have yet to be finalized by the project team and those provided during the workshop had missing elements (by gear, strata) and could not be traced to estimates provided in the report and workshop presentations.

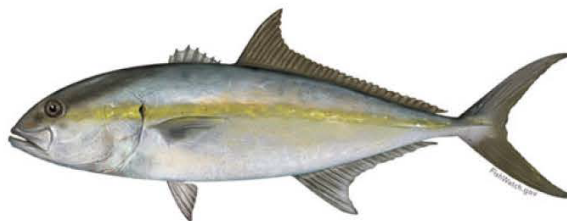
More importantly, this study suffered from the exact same issues as recent attempts to estimate abundance of Red Snapper using camera gears in the Gulf and South Atlantic. More effort should have gone towards defining ESA and FOV for the camera gears. The acoustic estimates developed were considered unreliable because of a lack of taxonomic specificity and acoustic 'dead zones'. Even if the project team were able to coordinate and produce final estimates in time for this review for all regions and strata, these fundamental issues of using optical and acoustic gear would still remain.

How does the variability and uncertainty compare to the current stock assessment.

The variability in the estimates are too high to inform the stock assessment. The estimates of CV are unreliable and biased low, and even then they do not meet a threshold of <0.3 , the level at which a stock assessment model might be influenced by the data point.

2.4 ADDENDA

Supplemental information provided to the Review Panel by the GAJ Count project team.



Greater Amberjack Abundance, Distribution, and Movement in U.S. Waters in the South Atlantic and Gulf of Mexico

S. Powers, M. Albins, K. Boswell, J. Buckel, M. Catalano, G. Chiu, M. Dance, M. Drymon, J. Hoenig, S. Midway,
S. Murawski, N. Phillips, J. Rooker, E. Saillant, S. Scyphers, L. Stokes, G. Stunz, T. Switzer, D. Wells



Greater Amberjack Review Workshop: Addendum

- Additional presentation slides prepared and presented during workshop in response to reviewer requests:
 - Table with best (to date) abundance estimates and associated CVs by region, with notes on decision points and modifications
 - Note: these numbers will likely change before final report submission as the project team is still in the process of refining the estimation methods
 - Estimated abundances from SEDAR 70 and 59 provided as context for above
 - Regional size distributions from camera surveys

Current region-scale abundance estimates for camera-only and camera-corrected-acoustic gears

Estimate	Region	Estimate	SE	CV	Decisions and modifications (compared to pres.)
Camera-only	Western Gulf	1,589,054	631,088	39.7	Max distance ESA used, SE calculation corrected, UCB excluded
	Alabama-Mississippi	216,164	106,847	49.4	C-stratum removed, only GAJ design used
	Western Florida	688,934	159,390	23.1	50m buffer used
	Total Gulf	2,494,152	659,616	26.4	
	South Atlantic	2,416,328	TBD	TBD	SBRUV only (no SERFS)
Camera-corrected Acoustic	Western Gulf	572,923	118,601	20.7	Hybrid species ratio, UCB included
	Alabama-Mississippi	371,286	51,901	14.0	Ratio est. C-stratum removed
	Western Florida	81,130	43,083	53.1	Estimate for Big-Bend stratum only
	Total Gulf	1,025,339	136,440	13.3	
	South Atlantic	1,032,506	TBD	TBD	

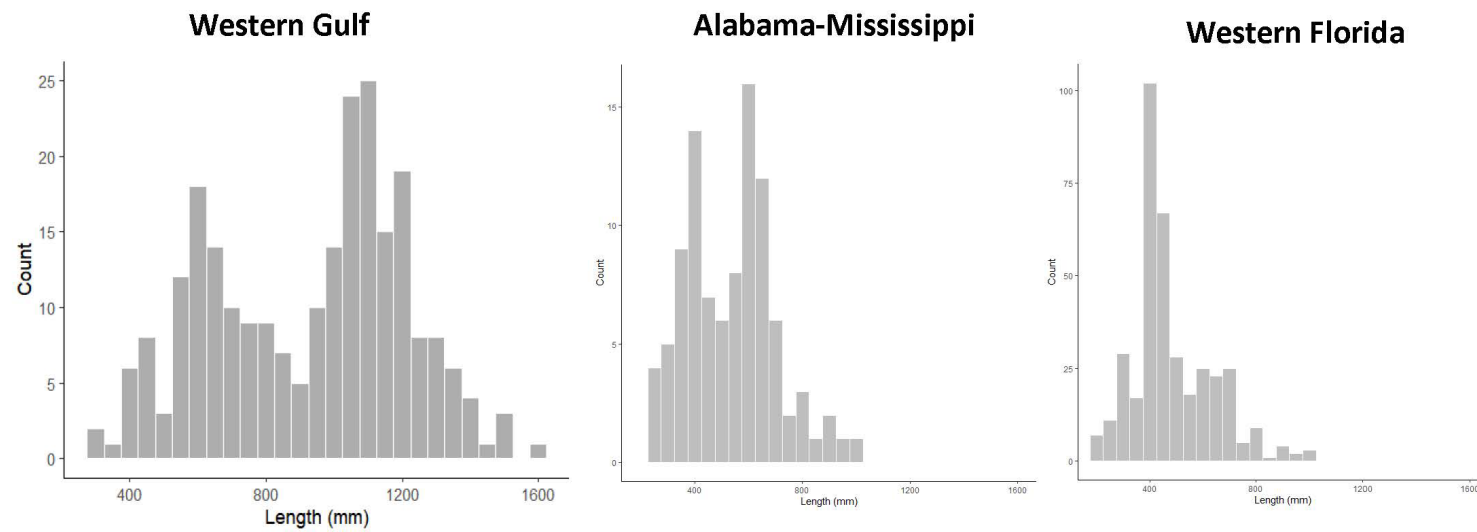
SEDAR 70



Table 12 Continued. Predicted biomass (metric tons), spawning stock biomass (SSB, metric tons), abundance (1000s of fish), age-0 recruits (1000s of fish), and SSB ratio (SSB/SSB₀) for Gulf of Mexico Greater Amberjack.

Year	Biomass	SSB	Abundance	Recruits	SSB/SSB ₀
1987	9,503	3,639	3,832	1,565	0.153
1988	6,851	2,495	2,259	5,912	0.105
1989	6,019	2,086	3,800	2,944	0.088
1990	5,827	1,513	3,157	962	0.064
1991	7,314	2,298	2,307	1,610	0.097
1992	6,624	2,826	1,951	1,240	0.119
1993	5,088	2,408	1,530	1,579	0.101
1994	3,807	1,621	1,481	1,190	0.068
1995	3,464	1,327	1,341	870	0.056
1996	3,591	1,413	1,168	1,533	0.060
1997	3,501	1,433	1,360	1,992	0.060
1998	3,626	1,391	1,694	1,243	0.059
1999	4,223	1,495	1,554	3,675	0.063
2000	4,883	1,662	2,612	4,267	0.070
2001	6,194	1,896	3,509	2,294	0.080
2002	7,753	2,440	3,102	1,727	0.103
2003	7,974	3,032	2,506	2,289	0.128
2004	6,537	2,801	2,308	1,284	0.118
2005	5,628	2,413	1,797	1,628	0.102
2006	4,556	1,841	1,643	2,683	0.078
2007	4,217	1,538	2,103	2,357	0.065
2008	5,049	1,685	2,310	2,643	0.071
2009	5,942	2,060	2,565	1,878	0.087
2010	6,951	2,757	2,395	1,323	0.116
2011	5,803	2,394	1,809	2,099	0.101
2012	5,560	2,463	1,975	2,135	0.104
2013	5,633	2,475	2,113	1,665	0.104
2014	5,267	2,113	1,904	2,272	0.089
2015	5,386	2,197	2,132	1,053	0.093
2016	5,330	2,238	1,667	1,020	0.094
2017	4,847	2,199	1,372	1,244	0.093
2018	4,850	2,432	1,385	1,813	0.103

Regional size distributions:



SEDAR 59



Table 6. Estimated total abundance at age (1000 fish) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	Total
1980	1401.81	613.63	324.18	178.68	104.28	63.26	39.15	24.72	15.76	28.53	2793.99
1981	1401.81	599.32	327.86	182.87	107.09	64.99	40.22	25.39	16.19	29.31	2795.06
1982	1400.84	603.48	303.09	166.10	97.77	59.50	36.84	23.26	14.83	26.84	2732.54
1983	1398.66	606.65	324.67	172.59	99.86	61.06	37.91	23.94	15.27	27.63	2768.23
1984	1401.64	612.87	331.95	191.46	108.02	64.97	40.52	25.67	16.37	29.63	2823.10
1985	1404.59	603.55	332.18	191.75	116.83	68.48	42.01	26.73	17.10	30.97	2834.19
1986	1405.38	605.47	323.39	187.86	114.66	72.59	43.40	27.16	17.46	31.71	2829.07
1987	1402.81	548.74	307.68	163.51	98.32	62.19	40.16	24.49	15.48	28.31	2691.68
1988	1395.90	587.86	290.93	163.96	85.98	53.18	34.29	22.59	13.92	25.13	2673.73
1989	1391.06	602.97	299.95	143.25	78.73	42.41	26.73	17.58	11.70	20.43	2634.81
1990	1609.75	602.54	308.20	145.65	65.84	37.00	20.31	13.06	8.68	16.01	2827.04
1991	1712.31	684.49	262.76	105.07	42.75	19.51	11.16	6.25	4.06	7.75	2856.11
1992	1530.62	715.00	353.15	114.50	34.80	14.00	6.50	3.79	2.15	4.09	2778.61
1993	1297.42	642.42	363.69	148.01	35.65	10.68	4.37	2.07	1.22	2.03	2507.55
1994	1080.29	550.47	340.22	177.83	61.52	14.90	4.55	1.90	0.91	1.44	2234.02
1995	985.41	466.67	288.06	164.73	74.75	26.09	6.44	2.00	0.84	1.05	2016.05
1996	690.46	421.69	251.56	150.34	77.12	35.48	12.62	3.18	1.00	0.96	1644.39
1997	674.93	284.15	215.57	120.12	65.57	34.21	16.04	5.82	1.48	0.92	1418.82
1998	1315.89	291.59	154.72	115.77	58.73	32.58	17.32	8.28	3.04	1.26	1969.19
1999	1305.32	568.36	157.82	82.59	56.96	29.41	16.62	9.02	4.36	2.28	2232.75
2000	1184.76	550.68	289.99	75.64	36.74	25.83	13.59	7.84	4.29	3.19	2192.56
2001	2116.92	506.04	293.55	152.27	37.43	18.57	13.30	7.14	4.16	4.01	3153.41
2002	1035.96	917.48	259.74	144.08	70.94	17.83	9.02	6.59	3.57	4.13	2469.36
2003	807.16	441.18	480.01	132.67	70.37	35.47	9.09	4.69	3.46	4.09	1988.19
2004	887.85	338.20	233.03	253.99	69.25	37.77	19.41	5.07	2.64	4.30	1851.52
2005	782.42	378.32	183.96	129.82	138.70	38.85	21.60	11.32	2.99	4.13	1692.12
2006	1897.35	332.65	206.92	103.43	71.37	78.29	22.35	12.68	6.71	4.27	2736.02
2007	1740.63	816.14	166.47	99.31	49.35	35.08	39.24	11.43	6.55	5.73	2969.92
2008	1768.64	750.03	425.51	85.80	50.28	25.69	18.61	21.24	6.25	6.78	3158.84
2009	1253.02	733.95	392.11	218.87	42.84	25.76	13.41	9.92	11.43	7.08	2708.39
2010	1444.55	523.73	389.81	208.42	113.64	22.84	14.00	7.44	5.55	10.47	2740.45
2011	1157.35	617.77	270.01	194.63	100.47	56.17	11.51	7.20	3.86	8.40	2427.36
2012	2091.73	500.10	339.34	152.85	107.51	56.96	32.46	6.78	4.28	7.38	3299.41
2013	1601.74	903.67	266.45	181.64	80.04	57.82	31.23	18.16	3.83	6.65	3151.24
2014	2395.87	687.09	486.85	146.31	98.40	44.59	32.84	18.09	10.62	6.20	3926.85
2015	1815.80	1017.07	365.55	260.23	76.70	53.00	24.48	18.39	10.24	9.61	3651.06
2016	1383.63	749.95	529.40	189.36	134.47	40.84	28.77	13.56	10.29	11.21	3091.48
2017	1138.59	564.39	387.99	271.84	97.43	71.34	22.09	15.88	7.56	12.11	2589.21
2018	1401.47	463.43	296.75	205.67	144.73	53.50	39.94	12.62	9.16	11.46	2638.74

Partitioning Size-Specific Abundances

- Stereo-measurement data not routinely collected by SERFS
- Very limited measurement data from FWRI survey
- Partitioning abundances by size/age not recommended at present

