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***SEDAR 87 Gulf White, Pink, and Brown Shrimp Benchmark
Assessment Independent Peer Review***

Tampa Bay, Florida

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Representing the Center for Independent Experts (CIE)

Executive Summary

The SEDAR 87 assessment review workshop was a Center of Independent Experts (CIE) assessment review of the Benchmark Assessment of Gulf of America white, pink, and brown shrimp that has been conducted by the Southeast Data and Assessment and Review (SEDAR). The term review is applied broadly, as the review panel (RP) was able to request additional analyses, error corrections and additional runs of the assessment models provided by the assessment panel.

The CIE organized three reviewers to conduct the peer review. On the 29 May 2025, the Gulf Council made available on the SEDAR website (<https://sedarweb.org/>) most of the background information relating to the data collection, manipulation and modelling for the three stock assessments. Additional papers were also supplied by email on the 22nd of June 2025. The background information was extensive and included all material required to conduct the review (see Appendix 1 for complete list). The CIE Review Panel (RP) participated in a workshop held in Tampa, Florida. The meeting was held at the Gulf of Mexico Fishery Management Council's office: 4107 West Spruce Street Suite 200, Tampa, FL 33607. The meeting began at 1 pm on Monday, June 23rd and ended at 10:30 am on Friday, June 27th. Live streaming of the workshop was available, and all meetings were recorded.

The SEDAR assessment scientists (AS) presented key aspects of their research on the first day. Copies of the presentations were provided to the review panel (RP) via the SEDAR website (<https://sedarweb.org/documents/sedar-87-review-workshop-gulf-brown-white-and-pink-shrimp-introduction-presentation/>). The RP were able to discuss and query aspects of the presentation as it was being delivered. The AS continued to present their research on the second day in addition to providing some analytical feedback from questions posed by the RP on day one. The last three days of the review consisted of discussions concerning the assessment models, assessment outcomes and the results of additional analysis requested by the RP during days two to four.

The RP found that the process conducted by SEDAR to be extremely thorough and expansive, conducted in a very structured and outcome-driven format in keeping with best practice. By building on an initial data workshop structured around specific terms of reference (TOR), and including experts from various stakeholder groups, SEDAR ensured the development of a comprehensive and valuable report from which the stock assessment could be developed (<https://sedarweb.org/documents/sedar-87-gulf-of-mexico-white-pink-and-brown-shrimp-data-workshop-report/>). This was followed by three separate assessment workshops, one for each shrimp species being examined. These workshops were also structured around well-defined TORs to ensure that a consistent process was followed and key objectives achieved. Clear and concise reports from all three assessment workshops were compiled and published on the SEDAR website along with numerous supporting documents.

The data collated for the assessment was examined and refined to produce commercial landings and fishery independent survey data sets that could be truncated by species and size class on broad spatial scales. Environmental datasets were developed for salinity and

water temperature in key juvenile habitats. The types of robust datasets identified directed the AS to using data-moderate assessment tools such as surplus production models, as more integrated modelling formats required a wider range of data. The AS decided on two modelling streams, VAST + JABBA and GP-EDM. The RP considered these choices were appropriate for use in this assessment. The RP were not of the opinion that other techniques should have been investigated by the AS.

The two modelling streams were found to have been developed and implemented correctly considered the datasets available for analysis. The RP provided some minor suggestions associated with the datasets used as inputs into VAST and its implementation, which included reducing the amount of uninformative data and trialling a month-year interaction. The AS considered these ideas and tested those easy to implement within the review workshop. Modifications provided slight improvements to the standardised indices generated, but the improvements were not influential enough as to impact the overall assessment on the shrimp stocks.

The RP also provided some suggestions for improvements to the JABBA modelling process, with again, those that could be examined easily, being done within the review workshop. One suggestion, concerning the testing of a previously fixed prior via sensitivity analyses resulted in improved model diagnostics and was subsequently adopted by the AS. Additional suggestions could not be examined within the workshop and have been listed in the research recommendations.

The use of GP-EDM as a stock assessment tool was extremely novel and much of the workshop consisted of discussing this process and building a more thorough understanding of the assumptions and implications of this technique, which has not previously been formally used for an assessment. The RP approved of its use and implementation, although retained some reservations due to its use in fisheries science being very immature. Specific concerns were the construction of the population delay embedding map as a function of survey indices and the timing of how these linked with commercial landings to estimate escapement in the following timestep, as well as the use of a scaling parameter to link escapement to catch (the method by which the index can inform on population size). There was also concern centred around whether the length of the timeseries available contained enough historical information (historical states) to accurately inform projections, especially under the scenario of a changing climate. Since the models were developed using data sets up to the 2022 calendar year, the opportunity exists to employ these models to estimate abundance indices for 2023 and 2024, and compare these to observed indices that can be produced from already conducted surveys. This could not be completed within the review workshop and remains a research recommendation.

There were no major flaws found in the assessment process and the suggestions made by the RP are not likely to markedly change the management implications of the assessments. Adopting the research recommendations will result in small changes and provide increased robustness to the assessments. For each of the three shrimp species the assessment indicated these stocks are most likely being exploited at levels below MSY,

are not in an overfished condition and overfishing is not occurring. This assessment was based on both the outputs of assessment models applied to the data and the consistent positive trends displayed in the raw and modelled index data sets. In coming to this conclusion, the RP considered the TORs listed in Appendix 2.

Background

The shrimp fisheries on the Gulf of America have historically been among some of the most important fisheries in American waters, with commercial landings reaching to nearly 200 million pounds of tails. Virtual Population Analysis (VPA) was first applied to the Gulf of America (GOA) shrimp fisheries in the 1980s (Nichols 1984, 1986; Nance & Nichols 1988; Nance 1989) and remained the model structure of choice well into the 2000s. VPA is an age-based model that aims to rebuild the historic population structure from its current state using age cohorts and estimates of natural mortality. A review of this assessment methodology was conducted in 2009 and found “the current VPA model cannot be considered to produce a reliable indicator of current shrimp abundance”.

Following this review, a new modelling framework was chosen in 2010, Stock Synthesis (SS: Methot et al., 2020), also an age-based model, but rather than projecting backwards, SS recreates the population from the start of the timeseries, which is often close to its virgin state. This statistical catch-at-age model tracks population composition in age cohorts, estimating recruitment and survival from one year to the next. Its integrated nature allows for the use of a range of data sources including recruitment indices, size and age compositions, indices of fishable biomass, and fishery landings (including discard mortality). An estimate of natural mortality and growth are required inputs for these models. SS has successfully been applied to many fisheries world-wide and is considered one of the premier modelling frameworks available. Nine years after first being applied to GOA shrimp, a review of this implementation was conducted and reported “analytical staff have found several concerning issues that must be addressed before developing new shrimp assessment models”. These findings were not too surprising since both age-based models were being applied to stocks for which age structure can only be implied and growth and natural mortality can vary markedly between years with changes in the environment. Furthermore, due to their short life span (<2 years) and recruitment being predominantly environmentally driven (not stock driven), it is very difficult to determine a stock-recruitment relationship, which drives recruitment in SS.

The 2019 review decided that different approaches were needed, which led the Southeast Fisheries Science Center (SEFSC), in conjunction with the Gulf Council, to structure a series of stakeholder workshops beginning in 2021. These workshops systematically examined all aspects of available data that could be used in the assessment process, namely, landings, commercial effort, indices of abundance, shrimp life history, environmental indices and bycatch. A summary workshop (SEDAR 87 Data Workshop) was held in was held in 2023 in Tampa, FL. In addition to the in-person workshop, a series of webinars were held before (August 2023) and after (November 2023 – May 2024) the meeting.

The identification of robust datasets during the data workshop directed the assessment scientists (AS) towards data-moderate assessment tools such as surplus production models that require information on landings and an index of abundance only. The AS decided on two modelling streams, VAST to inform JABBA and GP-EDM. Assessment development and subsequent workshops for GOA brown, pink and white Shrimp were then conducted via a series of webinars held between October 2024 and February 2025. SEDAR then requested the Centre for International Experts (CIE) to conduct an independent review of this entire benchmarking process from data identification through to model development and assessment of stock status.

Three CIE reviewers conducted the peer review in accordance with the Terms of Reference (TORs) (see Appendix 2). Approximately three weeks before the peer review, SEDAR made available via both email and their website (<https://sedarweb.org/assessments/sedar-87-gulf-of-mexico-white-pink-and-brown-shrimp/>) all necessary background information and reports for the peer review. The CIE reviewers participated in a panel review held in Tampa, Florida. The meeting was held at the Gulf of Mexico Fishery Management Council's office: 4107 West Spruce Street Suite 200, Tampa, FL 33607. The meeting began at 1 pm on Monday, June 23rd and ended at 10:30 am on Friday, June 27. Live streaming of the workshop was available, and all meetings were recorded.

The CIE reviewers were joined by a reviewer from Louisiana Parks and Wildlife (Eric Lang) with the panel being chaired by Jim Tolan from Texas Parks and Wildlife (collectively referred to as the review panel: RP). The RP met with key assessment scientists (AS) Molly Stevens, Lisa Ailloud and their supervisor Katie Siegfried. A third AS attended the meetings online (Steve Munch). Observers were also present through most of the review workshop, both in person and online (Appendix 4). The AS presented the key aspects of their research on the first day according to the agenda in Appendix 5. Copies of the presentations were provided to the reviewers (<https://sedarweb.org/documents/sedar-87-review-workshop-gulf-brown-white-and-pink-shrimp-introduction-presentation/>). The RP were able to discuss and query aspects of the presentation as it was being delivered. The AS continued to present key aspects of their research on the second day in addition to providing some analytical feedback from questions posed by the RP on day one. The last three days of the review consisted of discussions concerning the assessment and feedback of requests being posed to the AS during days two to four. Additionally on day four each member of the RP provided the chair with a section for a group report which would be structured around the TORs for the review (Appendix 2) and presented directly to SEDAR three weeks following the workshop. The RP reconvened on day five to review this group report and provide the chair with additional information.

The report generated by reviewers addressed the following TORs:

1. *Evaluate the degree to which the terms of reference from the Data and Assessment processes were addressed.*
2. *Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions. Consider the following:*
 - (i) *Are data decisions made by the Data and Assessment processes justified?*
 - (ii) *Are data uncertainties acknowledged, reported, and within normal or expected levels?*
 - (iii) *Is the appropriate model(s) applied properly to the available data?*
 - (iv) *Are input data series sufficient to support the assessment approach?*
3. *Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, given the available data. Consider the following:*
 - (i) *Are methods scientifically sound and robust?*
 - (ii) *Are priority modeling issues clearly stated and addressed?*
 - (iii) *Are the methods appropriate for the available data?*
 - (iv) *Are assessment models configured properly and used in a manner consistent with standard practices?*

4. *Consider how uncertainties in the assessment, and their potential consequences, are addressed.*
 - (i) *Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.*
 - (ii) *Comment on the likely relationship of this variability with possible ecosystem or climate factors and possible mechanisms for including this into management reference points.*
5. *Provide, or comment on, recommendations to improve the assessment*
 - (i) *Consider the research recommendations provided by the Data and Assessment processes in the context of overall improvement to the assessment, and make any additional research recommendations warranted.*
 - (ii) *If applicable, provide recommendations for improvement or for addressing any inadequacies identified in the data or assessment modeling. These recommendations should be described in sufficient detail for application, and should be practical for short-term implementation (e.g., achievable within ~6 months). Longer-term recommendations should instead be listed as research recommendations above.*
6. *Provide recommendations on possible ways to improve the Bench-Mark Assessment process.*
7. *Prepare a Review Workshop Summary Report describing the Panel's evaluation of the Research Track stock assessment and addressing each Term of Reference.*

Summary of Findings

The findings of the review have been reported following the terms of reference set for the review workshop, with research recommendations summarized under TORs 5 and 6. The terms of reference were:

1. Evaluate the degree to which the terms of reference from the Data and Assessment processes were addressed.

The Data and Assessment Terms of Reference (TOR) are listed in Appendix 2. They were comprised of eight and nine TORs, respectively. Below are comments (text in blue) relevant to each TOR and its respective sub-components (identified in black).

Data Workshop TORs

DW1. Gather data through 2022 (where possible) for Gulf of Mexico White, Pink, and Brown shrimp.

All available data on shrimp in the Gulf of America was collated, discussed and decisions as to each index's value to the assessment were determined in a data-specific workshop. This workshop (SEDAR 87 Data Workshop) was held September 18-22, 2023, in Tampa, FL. In addition to the in-person workshop, a series for webinars were held before (August 2023) and after (November 2023 – May 2024) the meeting.

DW2. Review, discuss, and tabulate available life history information for each stock being assessed.

- Evaluate growth data where available. Determine the adequacy of available life history information for different types of assessment or population model.

Growth data did not appear to have been discussed during the assessment process (or was not reported upon). This was likely to be due to the methods chosen for the assessment not requiring growth information (data moderate assessments). Furthermore, since the requirements of the chosen models were landings, indices of abundance and environmental drivers of production, only those life history components relative to these inputs were required. These data streams were collated with discussions as to their suitability and flaws provided in the data workshop reference document SEDAR87-RD-11.

- Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source.

All available data on shrimp in the Gulf of America was collated, discussed and decisions as to each index's value to the assessment for shrimp was determined in a data-specific workshop. Each data series was examined based on set criteria by a range of experts in survey design, biology, shrimp fishing and fisheries assessment (over sixty participants). This ensured that unique aspects of each data set were clearly understood and could be considered against the selection criteria, with all associated consideration of data uncertainty and limitations listed under "Comments on Adequacy for Assessment" in the SEDAR Data Workshop Report.

DW3. Create a conceptual model based on feedback from a variety of industry representatives in the Data Workshop to capture their institutional knowledge. Conceptual models were built during the workshop and well described in data workshop reference document SEDAR87-RD-11. For each species these were listed under “Stock Assessment Configuration”.

DW4. Provide measures of population abundance that are appropriate for stock assessment.

- Consider all available and relevant fishery-dependent and -independent data sources. The applicability of relevant fishery-dependent and independent data sources was individually assessed and reported upon in the SEDAR Data Workshop Report.

- Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.

All programs evaluated were well described in a logical format in the SEDAR Data Workshop Report that covered program objectives, methods, coverage, and sampling intensity.

- Provide maps of fishery and independent survey coverage, where possible.

Overlay maps showing both commercial fishery coverage as well as independent survey coverage were provided in the SEDAR Data Workshop Report, as well as to the review panel via slides during the review workshop (<https://sedarweb.org/documents/sedar-87-review-workshop-gulf-brown-white-and-pink-shrimp-introduction-presentation/>)

- Develop fishery and survey CPUE indices by appropriate strata (e.g., area) and include measures of precision and accuracy.

Survey indices of abundance were developed using VAST, which allowed for the strata to be defined and produced measures of uncertainty and reported in species-specific reports: SEDAR 87 – 03, 04, 05. The precision associated with all data was discussed and reported in the SEDAR Data Workshop Report.

- Provide appropriate measures of uncertainty for the abundance indices to be used in stock assessment models.

Appropriate measures of uncertainty for survey indices of abundance were provided in reports: SEDAR 87 – 03, 04, 05.

- Document pros and cons of available indices regarding their ability to represent abundance.

The pros and cons of each available index were thoroughly discussed at the data workshop and reported in the SEDAR Data Workshop Report. This report identified which indices were considered appropriate as inputs for the assessment.

- For recommended indices, document any known or suspected temporal patterns in catchability not accounted for by standardization.

All temporal patterns were assessed during the VAST modelling process. These were clearly reported in SEDAR87 – 03, 04, 05 reports.

- Provide appropriate measures of uncertainty for the abundance indices.

Appropriate measures of uncertainty for survey indices of abundance were provided in reports: SEDAR 87 – 03, 04, 05.

DW5. Provide commercial catch statistics for each stock where possible. Document species-specific issues.

Commercial shrimp landings by species and size bin were developed on broad spatial scales. These data were outlined and discussed in the SEDAR Data Workshop Report, including levels of uncertainty in reporting and possible issues in accuracy and completeness.

- Provide maps of fishery effort and harvest by sector and/or gear by species, where possible.

Maps showing fishing effort based on the eELB data collection method and landings derived from the Gulf Shrimp System (GSS) and State Ticket System (STT) were provided in maps provided in the SEDAR Data Workshop Report.

- Provide estimates of uncertainty around each set of landings and effort estimates. Since commercial effort was not used in the assessment, associated levels of uncertainty were discussed but not formally reported. Uncertainty associated with commercial landings was discussed at the Data workshop and “time blocking” estimates were developed that progressively declined from 20% in the 1960s, to 5% in recent years.

DW6. Describe any known evidence regarding ecosystem, climate, species interactions, habitat considerations, species range modifications and/or episodic events that would reasonably be expected to affect shrimp population dynamics, and the effectiveness of reference points.

- Provide species envelopes, i.e., minimum and maximum values of environmental boundaries (e.g., depth, temperature, substrate, relief) based on observations of occurrence.

Species envelopes were well identified, described and reported in SEDAR87-RD-11 which was provided to the SEDAR Data Workshop. The rate of environmental change occurring within the GOA and how this may impact shrimp stocks, and the associated value of management reference levels was not reported upon in the SEDAR Data Workshop Report.

- Develop hypotheses to link the ecosystem and climatic events identified in addressing this TOR to population and fishery parameters that can be evaluated and modeled. The hypotheses linking shrimp productivity to ecosystem events were discussed and water temperature and salinity within the estuarine environment were identified as most likely drivers that could be used in the modelling framework. It was considered most likely that the strongest links would occur between post larval shrimp and their associated environment.

DW7. Integrate economists into the stock assessment model development process in order to

explore models that can address questions such as benefits of seasonal/spatial closures, impacts of fuel prices on total effort, and ex-vessel prices of different market categories, if possible.

- Detail the early 2000 industry consolidation and impacts of ex-vessel price on effort. Ex-vessel prices are discussed under 5.3.5 Shrimp Price Indices and shown in Figure 2 of the SEDAR Data Workshop Report. The value of using maximum economic yield (MEY) as a management reference level, which would allow for the benefits of

spatial/temporal closures to be examined, was not reported upon in the SEDAR Data Workshop Report.

DW8. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment.

Research recommendations were reported under 4.6 RESEARCH RECOMMENDATIONS of the SEDAR Data Workshop Report.

DW9. Prepare a Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines.

A document was produced following the Data Workshop (SEDAR Data Workshop Report - <https://sedarweb.org/documents/sedar-87-gulf-of-mexico-white-pink-and-brown-shrimp-data-workshop-report/>).

Assessment Workshop TORs

AW1. Review any changes in data or analyses following the Data Workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

Three documents (one per species) were developed and published on the SEDAR website which list summaries of the data inputs (and units) used in the assessment modeling process along with their corresponding available temporal scale based upon recommendations from the Data Workshop process. The documents were [SEDAR 87 Gulf Brown Shrimp Assessment Process Report](#), [SEDAR 87 Gulf White Shrimp Assessment Process Report](#), and [SEDAR 87 Gulf Pink Shrimp Assessment Process Report](#).

AW2. Develop a management advice framework. Consider data availability (e.g., landings and CPUE) and management needs (e.g., harvest controls, stock status), and particular needs of the fishery and the biology of the resource.

The structure of management advice and how it relates in these species, especially in relation to their highly dynamic reproductive capacity, was discussed for each species in their respective Assessment Process Reports listed above.

AW3. Examine the impacts of social science factors on biological reference points as informed by stakeholders through industry input.

The time series of imports and ex-vessel prices were both considered during GP-EDM development to incorporate social science factors into the development of reference points. However, in the final model versions, these data were not directly used in the projections used to calculate MSY. That said, based on Taken's theorem (Taken, 1981), the lags used in EDM contain historic information on drivers which would include all social science factors. Therefore, in theory if in the history of data used the fishery had experienced a range of social science factors (variable shrimp demand, high and low fuel costs, etc.) these would have been included in the projections.

AW4. Recommend biological reference points for use in management

- Consider how reference points could be affected by management, ecosystem, climate, species interactions, habitat considerations, social or economic drivers, and/or episodic events.

It was highlighted within the species-specific shrimp Assessment Process Reports that static biological reference points may not be appropriate under scenarios when stock abundance changes due to environmental/habitat drivers on recruitment. The longer-term environmental changes due to climate change were not discussed.

AW5. Provide estimates of stock population parameters, including: Fishing mortality, biomass, selectivity, and/or other parameters as necessary to describe the population.

The Assessment Process Reports for each species contain substantial information (e.g., stock parameters, indices and biomass trends) that can be used to describe relative population trends. For all species, standardised index outputs from the VAST modelling, provided a relative measure of stock trajectories. These alone inform on population dynamics. Importantly, the reports progressed through the assessment process outlining which models converged, and based on well documented criterion, were classified as appropriate for assessment. This was a hierarchical process, with information valuable for assessing the stock progressively increasing in concert with model complexity as they passed the selection criterion. Where models converged, comprehensive summaries of model diagnostics and stock population parameters were provided in the relevant Assessment Process Reports.

AW6. Characterize uncertainty in the assessment and estimated values.

- Consider uncertainty in input data, modeling approach, and model configuration.

Outputs from the VAST + JABBA and GP-EDM modelling processes (where conducted) were all presented with associated levels of uncertainty in the relevant Assessment Process Reports.

- Provide appropriate measures of model performance, reliability, and ‘goodness of fit’.

A very thorough, clearly defined and in some cases novel (required for GP-EDM as standard procedures are yet to be defined) process was used to examine model performance and quality of fit. Scenario matrices were used to test the sensitivity of priors, multiple measures were used to assess goodness of fit, and retrospective analysis and prediction strength were used to understand model performance and reliability.

- Provide measures of uncertainty for estimated parameters and derived quantities such as biological reference points and stock status if feasible.

All estimated quantities (e.g., parameters and indices) were produced and presented with their associated levels of uncertainty in the relevant Assessment Process Reports.

AW7. Provide recommendations for future research and data collection. Emphasize items that will improve future assessment capabilities and reliability. Consider data, monitoring, and assessment needs.

For each species a set of clear future research recommendations were documented and reported in a specific report in the report series (SECTION IV: Research Recommendations). These recommendations are designed to benefit future assessments.

AW8. Complete an Assessment Workshop Report in accordance with project schedule deadlines

Three documents (one per species) were developed and published on the SEDAR website: [SEDAR 87 Gulf Brown Shrimp Assessment Process Report](#), [SEDAR 87 Gulf White Shrimp Assessment Process Report](#), and [SEDAR 87 Gulf Pink Shrimp Assessment Process Report](#).

2. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions. Consider the following:

(i) Are data decisions made by the Data and Assessment processes justified?

The selection of data sources was conducted via a thorough and comprehensive workshop process that can be considered best practise and appropriate. A similar such process should be used for future assessments.

All available data on shrimp in the Gulf of America was collated, discussed and decisions as to each index's value to the assessment for shrimp was determined during the data workshop. This workshop (SEDAR 87 Data Workshop) was held September 18-22, 2023, in Tampa, FL. In addition to the in-person workshop, a series for webinars were held before (August 2023) and after (November 2023 – May 2024) the meeting. Sixteen workshop papers and eleven workshop reference documents were made available for the workshop. Appropriate data series to be used in the subsequent stock assessments were chosen based on a set of clear selection criteria, namely:

- Temporal range,
- Spatial range,
- Consistent survey design (e.g., fixed sampling sites, stratified random etc.),
- Standardized sampling methodology (e.g., gear, vessel, effort, etc.),
- Ages and/or sizes represented.

The workshop included a wide range of experts in survey design, biology, shrimp fishing (including industry representatives) and fisheries assessment (over sixty participants). This ensured that unique aspects of each data set were clearly understood and could be considered against the selection criteria.

The key data sets chosen to represent landings were Gulf Shrimp System (GSS) and State Ticket System (STT), with the latter being considered more accurate. As such, once STT was considered fully operational for an entire season in a state, this was used preferably over GSS. Limitations in landings data (such as unreported catch, miss-identification, etc.) were discussed and not considered to be significant. All catch landings were

converted to head-off and binned into small, medium and large size-categories and one of three fishery statistical areas by weight. Binning was required to allow models to match variable targeting of shrimp species by size.

Index data chosen was limited to independent surveys primarily due to their accurate recording of effort and spatially structured design; the Southeast Area Monitoring and Assessment Program (SEAMAP), Texas Parks and Wildlife Gulf trawls (TPWG) and Louisiana Department of Fisheries and Wildlife (LDFW). A small complication existed with the SEAMAP data set in that the structure was changed slightly in 2008 (survey expanded eastwards and diel structure changed). These changes could be accounted for in the subsequent standardization process (VAST, see later). A second concern existed with a sample being missed in 2020 due to covid and could not be imputed using the model standardization process. This data point was subsequently averaged between adjacent summer samples from 2019 and 2021 by shrimp species/size stratum/fishing statistical block. This assumption is reasonable for larger shrimp sizes since there is substantial carryover of this cohort from one year to the next (e.g., large brown shrimp SEAMAP cpue significantly correlated with a lag of one year: $R^2=0.52$). However, since the abundance of small shrimp has a minimal relationship with adjacent years, this process is unlikely to be appropriate for this size group (e.g., small brown shrimp SEAMAP cpue had no correlation with a lag of one year: $R^2=0.01$). Possibly a better imputation may be derived based on the relationship between small shrimp abundance in summer and the abundance of small shrimp in the fall samples (e.g., small brown shrimp SEAMAP cpue had a stronger correlation: $R^2=0.15$). It should be noted that this process also produces a better correlation in the large cohort ($R^2 = 0.72$).

For each independent survey, index data was summarized into catch rates based on numbers / trawl time (minutes). Another possible construction of a catch rate index is weight / trawl time, which has the added advantage of being on the same scale as landings (weight). This was investigated within the review and was found to produce marginally different indices of abundance (Figure 1). Basing indices on weight rather than numbers places the index on a scale more commonly understood by industry, which helps with dissemination. Their use in subsequent modelling processes could be examined.



Figure 1. Comparison between using numbers or weight to develop raw indices of abundance for brown (left), white (middle) and pink shrimp (right).

It appears difficult for the AS to access the SEAMAP database, with requests for additional data extractions being protracted. This limitation reduces productivity and

leads to reduced opportunity to examine different formations of data. Time should be invested to increase the efficiency of SEAMAP data requests.

The assessment process consisted of two unique model streams; VAST + JABBA and GP-EDM with separate data decisions being made for each process. Under the VAST + JABBA process, data from multiple surveys could be utilised, as was the case for brown shrimp (SEAMAP and TPWG), whereas GP-EDM required the input of raw data from a single source and could therefore not incorporate the spatial information of each data set. VAST incorporates data by accounting for spatial and temporal heterogeneity in addition to covariates that represent either catchability or productivity. To standardise spatially specific survey data and develop a timeseries appropriate for use in JABBA, the VAST approach was appropriate and consistent with best practice. Care should be taken however to ensure the data used is appropriate for the index being derived. In the case of the VAST analysis for the three shrimp species, two objectives were identified, 1. derive an index appropriate for use in JABBA, and 2. determine environmental drivers of shrimp productivity.

For objective 1 it is important to use index data collected from an area consistent with the area being fished so that landings match the index data (a signal response to extraction by the index will be diluted if areas unfished are included in the index data). Matching area of survey to commercial effort was generally the process employed by the AS; however, further modification could occur for the SEAMAP sites used to create the pink shrimp index. Another consideration is the proportion of zero observations in the survey data. VAST is a delta-generalized linear mixed model that employs two linear predictors, one to model encounter probabilities and one for positive observations. Although these models are designed to deal with high proportions of zeros, they have been shown to be more efficient and have lower associated estimated variances as the proportion of zeros in the data is reduced (Feng 2021). The survey data should be examined for components that provide little to no information for the overall index. For example, both brown and pink shrimp burrow during the day and have much lower catchability than during the night. This diel activity is the reason commercial shrimp trawlers generally only operate during the night (Salini et al., 2001). It is likely that night trawls would contain a far lower proportion of blank (zero shrimp) shots and would therefore provide a better measure of variation in shrimp biomass between shots. In this case, the removal of day trawls from a data set with both day and night trawls will likely reduce the proportion of zeros in the data and result in a more precise standardized index of abundance. This was examined by the AS during the review workshop.

For objective 2, it is important to consider what components of the SEAMAP survey are expected to respond to changes in the environment and with what time lag. As shown in Figure 2, in many months of the year there exist multiple cohorts of white shrimp, with each cohort being derived from different periods in the estuarine environment. In this case, a single cohort that aligns with a time in the estuary should be identified and modelled using VAST to examine environmental drivers of shrimp productivity. This could be done by selecting only certain months, or by only modelling certain size classes in the data (size classes chosen based on cohort analysis).

In the current assessment when using VAST to test for relationships between stock abundance and environmental covariates in the assessment, due to the lagging of

environmental data one and two years, the first years of environmental data were unavailable (due to their being recorded prior to the time series). As such “The median of the time series was used as substitutes for the initial years that preceded lagged data availability (i.e., 1987 for the 1-year lag time series and 1987- 1988 for the 2-year lag time series)”. This substitution will reduce the power of the model to detect a relationship. Instead, a better process would be to shorten the timeseries by two years to allow for only observed data to be used in the model.

Under the GP-EDM process, unstandardised data was used to maintain the historical signals present in the timeseries. This can cause some issues if the data is not balanced, as was the case in the SEAMAP data when it expanded eastwards towards Florida and fall samples were not consistently collected until 2014 (summer samples started a few years earlier). As such, the data available for GP-EDM could only start in 2014. When making these “raw” indices, extra care should be taken to ensure the best data locations and timings are used (matching survey locations to the fishing industry / using samples that show a strong contrast between years - the use of day trawls or samples in areas that never catch shrimp should be avoided).

The GP-EDM modelling incorporates both index and catch data to determine escapement of that same size class of shrimp. Care needs to be taken, both in seasonal and annual model timeframes, to ensure the landings of a certain size composition correctly align with the index of the appropriate size cohort. For example, for GP-EDM model run G20023 (brown shrimp, seasonal with three size cohorts) it is likely that the SEAMAP summer small shrimp index is impacted by commercial landings of small shrimp which will then be expressed by the medium shrimp SEAMAP index in fall of that same year. The linkages between size cohorts and sample timing should be discussed with a shrimp biologist and/or examined with shrimp growth curves to determine the best alignment.

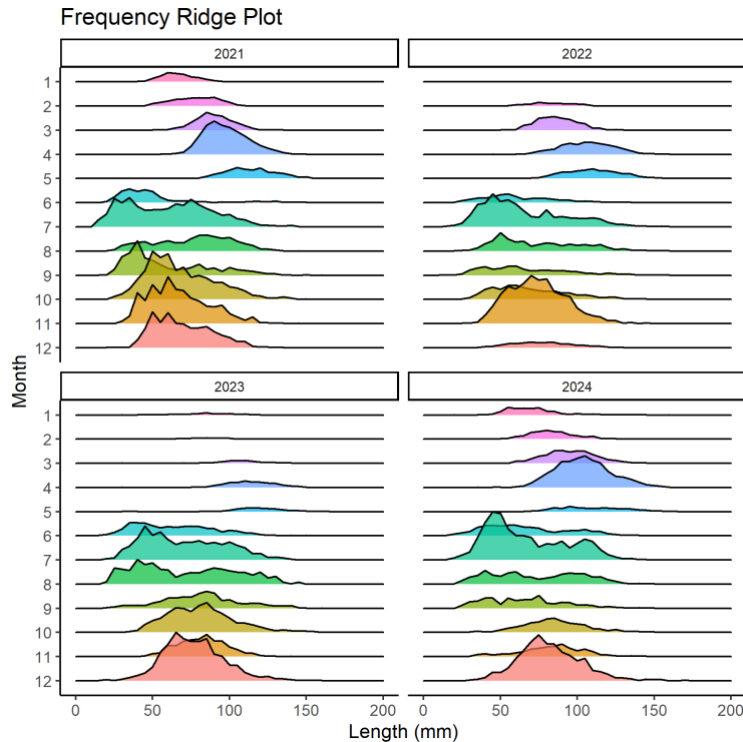


Figure 2. Texas independent gulf trawl survey white shrimp size frequencies for 2021 to 2024, showing different age cohorts being present in certain months, and multiple cohorts in some month/year combinations. Figure by Eric Lang.

(ii) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Data uncertainties were examined thoroughly during the data workshop and clearly listed and discussed in the workshop report and were within normal/expected levels. This process identified, for each dataset, a list of issues with associated recommendations for each issue, including their likely impact on the validity of the data, thus allowing for uncertainties in data to be identified and characterised. For example, uncertainty surrounding the accuracy of historic landings was discussed at length in the data workshop. SEDAR 87 Working Paper 6 outlined the process used to develop measures of uncertainty for certain periods of landings that ranged from 20% in the 1960s to 5% in the 2000s. There was some discussion within the review panel as to the adequacy of these levels of uncertainty, with one member having the view that landings could still be out by as much as 20%. Sensitivity analysis could be conducted using the final model versions (JABBA and GP-EDM) in which landings are perturbed to understand the sensitivity of benchmarks (e.g., B/B_{msy}) to variations in landing data.

(iii) Is the appropriate model(s) applied properly to the available data?

All fishery index data used in the assessment (SEAMAP, TPWG, LDFW) is collected and recorded spatially. Furthermore, these data contain a relatively large proportion of zero values (70%, 40%, 90%) for brown, white and pink shrimp, respectively. Such data requires a unique model structure as provided by VAST (i.e., spatial delta-generalized linear mixed model). This model structure can also incorporate habitat and catchability

covariates which can lead to more precise estimates of abundance. This standardisation method was used to produce a time-series of abundance for JABBA.

The assessment used two assessment models not previously used for Gulf shrimp (JABBA and GP-EDM) which both, as a minimum, only require landings and index data. JABBA implements a Bayesian state-space surplus production model and is specifically designed for data-moderate stock assessments based on landings and an index of abundance. It offers a flexible framework for estimating stock status and generating reproducible results. JABBA has been successfully used in other jurisdictions to conduct stock assessments on shrimp/prawns.

EDM is new to most fisheries biologists and can incorporate environmental, economic and other forms of data that drive the index being fitted. MSY reference points from GP-EDM were calculated by long term deterministic projections over a range of constant catch levels. GP-EDM has been used to investigate stock dynamics in some fisheries, but not to the extent conducted by the assessment team and never in a formal assessment process.

The choice of these models is appropriate based on the structure on the available data and their forms (landings and indices of abundance).

(iv) Are input data series sufficient to support the assessment approach?

The data available for brown and white shrimp appear sufficient to support the assessment approaches. The length of the index timeseries for pink shrimp, however, appears too limited to support the modelling approaches employed during this review, although it is sufficient to provide information as to the sustainability of current fishing practices. It was not possible to extend the temporal expanse of SEAMAP data for pink shrimp, nor does there appear to be other fishery-independent survey data available for the key areas of pink shrimp fishing. Furthermore, fishery-dependent indices of abundance have been examined and were discounted from further use during the data review process. Fishery-dependent data can be misleading, especially if landings and effort cannot be aligned both spatially and temporally (even if this can be achieved, changes in fishing behaviour also need to be accounted for). In a fleet that can spend many months at sea, matching catch (especially by size class as required by the GP-EDM model) to effort can be very difficult. Although the use of this data was examined during the data workshop, considering the temporal limitations of the SEAMAP data, it would be prudent to re-examine the fishery dependent data for pink shrimp. It should be noted that not all members of the fleet need to be utilised to construct a robust index of abundance, rather a subset of avid fishers with good record keeping processes, will produce a much better index than an entire fleet with constantly changing dynamics and drivers.

For short lived species with large variation in recruitment strength, the utility of reference points performs better with strong links to drivers of productivity (e.g., environment). Other factors that also impact reference points include economic and social factors that affect fishing practices, fishery selectivity and choice of fishing grounds. Such data were

used in some GP-EDM test runs but not in final GP-EDM or JABBA models used for determining reference points. This was because JABBA does not accommodate environmental data and future conditions for reference point projections in GP-EDM are uncertain. In theory, lagged survey data used as predictor variables in GP-EDM models carry some information about past environmental and economic effects, so, if these situations have been experienced within the data series, they are being incorporated.

3. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, given the available data. Consider the following:

(i) Are methods scientifically sound and robust?

Four methods were used in the stock assessment process: VAST, JABBA, GP and EDM. These are all proven and robust statistical methods, although the use of EDM in this case has novel aspects in its application.

VAST (Vector Autoregressive Spatio-Temporal model) is designed to produce standardized indices from catch rate data in which the data contains associated spatial information (Thorson, 2019). It is also a delta-generalized linear mixed model and is thus capable of dealing with data sets that contain a high proportion of blank (zero) samples. These facts make VAST especially useful for standardizing the fishery-independent datasets (SEAMAP, LDFW and TPWG) as these data contained very large proportions of zero values, about 70%, 40%, and 90% for brown, white and pink shrimp, respectively. Furthermore, in the case of brown shrimp, where both the SEAMAP and TPWD were considered appropriate for the assessment, VAST can combine different data sources via the use of catchability offsets and has been extensively tested, used in at least 48 stocks assessments with 130 published studies employing this technique (<https://github.com/James-Thorson-NOAA/VAST/wiki/Applications>). A number of these publications highlight the functionality of this method and its successful application to bottom trawl and more specifically, shrimp data (Cao et al., 2017; Thorson and Barnett, 2017).

JABBA (Just Another Bayesian Biomass Assessment) is an interface that combines a number of important components of a robust stock assessment; it is a relatively simple tool that uses a well-tested and understood methodology, requires a minimal number of assumptions, is implemented within a powerful structure (Bayesian State-Space) that not only produces the management information most often required, but also informative model diagnostics. The model requires time series of both landings and an index of abundance (such as that produced by VAST) and is therefore appropriate for this assessment. The primary reference for JABBA (Winker et al., 2018) has been cited in the literature at least 89 times and it has been used for the stock assessment of at least five shrimp/prawn fisheries (Zhou et al., 2020; Alam et al., 2022; Konoyima et al., 2022; Barua et al., 2023; Zhou et al., 2023).

Gaussian Process modelling (GP) is a regression process that helps estimate the latent (true) signal from noisy timeseries observations, with this denoised index being a more informative timeseries to be used as an input into the EDM modelling. GP modelling has been used extensively in fisheries science to study a range of factors including predator–

prey interactions, species distribution, growth functions and management decision-making (Pironen et al., 2022).

Empirical Dynamic Modeling (EDM) is based on the idea that the relationship between variables is state-dependent — meaning that their interactions can change depending on the system's current state. This nonlinearity makes traditional static modeling approaches inadequate. EDM leverages Taken's Theorem (1981), which states that the dynamics of a system can be reconstructed from time-lagged observations of a single variable. In other words, the influence of other variables is implicitly recorded in the history of the focal variable. By reconstructing this historical trajectory using lagged embeddings, it becomes possible to infer and forecast the system's behavior without explicitly modeling each driver. This assessment implemented this approach using GP-EDM (Gaussian Process Empirical Dynamic Modeling; Munch and Rodgers, 2025), which integrates Gaussian Process (GP) regression into the EDM framework. Although the application of this method in fisheries research is only a recent phenomenon, its use has now been published in at least five peer reviewed journals (Munch et al., 2018; Tsai et al., 2022; Han et al., 2023; Steele 2023; Tsai et al., 2024, with one paper based on the assessment of a shrimp species. A novel formulation was applied in this assessment which required both commercial landings and an index of abundance, thus making it appropriate for this assessment based on the data available.

(ii) Are priority modeling issues clearly stated and addressed?

All modelling issues were clearly stated with all modifications/adjustments made clearly outlined within the species-specific SEDAR 87 SAR Section III reports.

(iii) Are the methods appropriate for the available data?

As stated above under 3i, the models used were appropriate for the assessment of these stocks given the types of data available, with VAST capable of modelling spatially specific index data, GP for removing noise from index data and both JABBA and EDM requiring index data and commercial landings. The temporal scale of the data can in some cases be a limiting factor. JABBA (and all surplus production models) perform better if the time series being modelled contains contrast in both landings and index and are even more effective if this contrast occurs as both increases and decreases of the same variable (e.g., index). The shorter a time series is, the less likely it will contain the contrast needed for a robust assessment. For EDM the importance of timeseries length is that it is long enough to have experienced other states that the index may return to within the forecast window. If these states have not been experienced within the history of the time series, the model has no information and therefore limited ability to predict the timeseries under that state in the future. As EDM is applied to more datasets, generalizations can be made concerning the minimum timeseries length required, but in general terms a length of between 30 – 40 observations has been suggested (Sugihara et al., 2012). The longest timeseries used during these shrimp assessments (brown shrimp) could be used to examine the impact of fewer observations on resultant model projections.

- (iv) Are assessment models configured properly and used in a manner consistent with standard practices?

The configuration and implementation of the models is appropriate and consistent with standard practices, including the use of default priors, the implementation of a sensitivity matrix to undertake structured sensitivity analysis of both priors as well as model structure, and the extensive use of model diagnostics. This ensemble process (comparing model runs from a range of model structures with different priors) ensures that an average model assessment can be developed and an understanding of the influence of various decisions can be understood. The review panel suggested only minor modifications to model configurations/applications, namely: adding the prior on the Pella-Tomlinson shape parameter (m) into the sensitivity analysis of the JABBA modelling, examining a month-year interaction in the VAST model for brown shrimp and refining the production function used in the GP-EDM model.

The JABBA model uses the Pella-Tomlinson form of Surplus Production Model (SPM) which can replicate the multiple forms of SPM due to the m parameter, which adjusts the shape of the production function. If m is set to 2, the model collapses into a Schaefer SPM in which maximum sustainable yield (MSY) occurs when the biomass is $1/2$ carrying capacity (K). As this parameter decline towards 1, MSY will occur at smaller proportions of K . In the initial set of sensitivity analyses the prior on m remained constant (set to 1.19). Additional sensitivity runs with the prior on m being smaller (either 0.5 or 0.23) were conducted within the review process. This analysis showed that reducing the prior on m resulted in better model fit (based on model diagnostics). Furthermore, this sensitivity analysis highlighted a resilience of model estimates for brown shrimp MSY (e.g., 80-90 million pounds: MP) to variation in this parameter which increases confidence in this model estimate (MSY). As lower values were tested in pink and white shrimp models, the m parameter had the direct effect of scaling biomass estimates, impacting the relative metrics of F/F_{msy} and B/B_{msy} (noting that all JABBA models fitted to pink shrimp data were not considered appropriate for use in assessment due to poor model diagnostics).

The VAST model is used to standardise raw catch rate data across space and time and can account for additive factors that may impact either abundance or catchability. The VAST model for brown shrimp used two independent data series (SEAMAP and TPWG), with the former having data collected annually in two periods (summer and fall) and the latter monthly. A driver for combining the indices was to use the monthly structure in the TPWG data to inform the model in certain years (2005, 2007, 2010 and 2022) when the SEAMAP survey was conducted later than standard. These later surveys resulted in sampling being conducted after the start of the Texas fishing season, by which time the stock had presumably experienced some depletion from commercial fishing. Therefore, samples in these years were no longer representative of pre-fishing stock levels, unlike those collected in the other years of the survey, and the consistency of the survey had been broken. The VAST model can account for month of sampling in a stationary form, having the relative impacts between months constant over time. A stationary monthly pattern is possible, but in the scenario where fishing behaviour has changed markedly over recent years (moved to catching larger shrimp in more inshore areas and from West to East) it is more likely that monthly depletion rates have changed. As such, better

“corrections” for these delayed samples would be made by the model if they were based on contemporary monthly information rather than an average over the entire timeseries. The linkages between size cohorts and index sample time need to align properly for the index being modelled in GP-EDM to make biological sense. In the biomass dynamics equation used, $B_{t+1} = B_t - C_t + P(B_t - C_t)$, it appears that biomass and catch of small shrimp are used to inform biomass of small shrimp in the following timestep. In the seasonal formulation of the GP-EDM model, biomass is measured in summer and again in fall. Under this temporal structure small shrimp in summer will have grown into medium shrimp (and medium into large) by fall (the time the second biomass measure is measured). Therefore, a more realistic biomass dynamics may be, in the example of small shrimp, $B_{t+1}^M = B_t^S - C_t^S + P\left(B_t^S - \frac{C_t^S}{2}\right)$, where the biomass of medium (m) shrimp is a product of small (s) shrimp biomass in the previous timestep (t). Note the use of $\frac{1}{2}$ catch to approximate the average biomass in the timestep t rather than the biomass at the end of the timestep.

4. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- (i) Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.

The process followed by the AS (a series of workshops compartmentalising various stages of the assessment) ensured that uncertainty associated with the input data, modelling and the final population assessment was fully acknowledged and presented in the final product. Uncertainty in the data was examined and either estimated (landings) or determined using VAST (index data) to deal with high proportions of blank data (zero-inflated) and spatial correlation. Environmental drivers were examined to reduce uncertainty in inter-annual shrimp productivity and if possible, build this into the assessment model (GP-EDM). The use of JABBA with its Bayesian state-space formulation, provides the potential for a more accurate representation of uncertainty than “standard” surplus production model formulations by accounting for both process and observation error. Sensitivity trials in model structure and parameterisation for both the JABBA and GP-EDM models were employed to test different assumptions and to understand the influence associated with various model decisions. This was made possible by the relatively fast convergence abilities of both models.

JABBA is implemented in R via a user-friendly open-source tool that is hosted on GitHub (<https://github.com/jabbamodel>). An especially good aspect of this implementation is the functionality of its diagnostic and outputs plotting, all of which display associated uncertainty.

Although currently being in a far less developed state, GP-EDM is also implemented in the R platform via its own easy to use tool hosted on GitHub (<https://github.com/tanyalrogers/GPEDM>). This tool has some diagnostic and plotting functions inbuilt, and in time is likely to expand its functionality to match that of JABBA.

One area of uncertainty that is not fully accounted for in the assessments is that associated with the appropriateness of management reference points in a future state in

which the environment is progressively changing in one direction. Both the JABBA and GP-EDM models formally assume some level of stationarity, with the system being modelled either in a relatively stable state (JABBA – random effects can incorporate some drift) or within a state having been witnessed within the timeseries (GP-EDM). An expanded discussion concerning non-stationarity is provided below under (ii).

- (ii) Comment on the likely relationship of this variability with possible ecosystem or climate factors and possible mechanisms for including this into management reference points.

Studies have shown that the environment in the northern Gulf of America (GOA) has progressively changed in recent history. Sea floor water temperatures in the northern GOA, throughout the same areas frequented by the shrimp fishery, have increased on average by 0.5°C per decade between 1963 and 2015 (Eugene Turner et al., 2017). The intensity of hurricanes has increased (Malmstadt et al., 2010; Balaguru et al., 2022), while various water management systems have altered the flow of freshwater and nutrients into these productive shrimp grounds (Yin et al., 2023). It is thus likely that shrimp biology (e.g., reproduction, growth and maturation) has also changed, altering stock productivity, and thus management reference points. MSY in the 1960s, is highly unlikely to be similar to MSY in 2020, and future MSY is likely to be different again.

In the VAST modelling, environmental covariates were examined to elucidate drivers of productivity, but to no avail. This was surprising since previous analysis has detected positive relationships between shrimp abundance from the SEAMAP survey and tide data and negative associations between these data and water discharge data (Millberry, 2017). Other factors shown to have impacted shrimp abundance, albeit, on a slightly smaller spatial scale, include water temperature and wet land extent (Diop et al., 2007).

Moreover, the similarity in standardised SEAMAP indices produced by VAST modelling for brown and white shrimp show remarkably similar trends even through their respective fisheries recorded contrasting landings over this same period (brown landings declined while white landings increased) (Figure 3). This indicates that the modelled trends in biomass are strongly associated with changes in productivity that were synchronised for the two different species, and the most likely productivity driver(s) is/are having an impact over a wide geographic area.

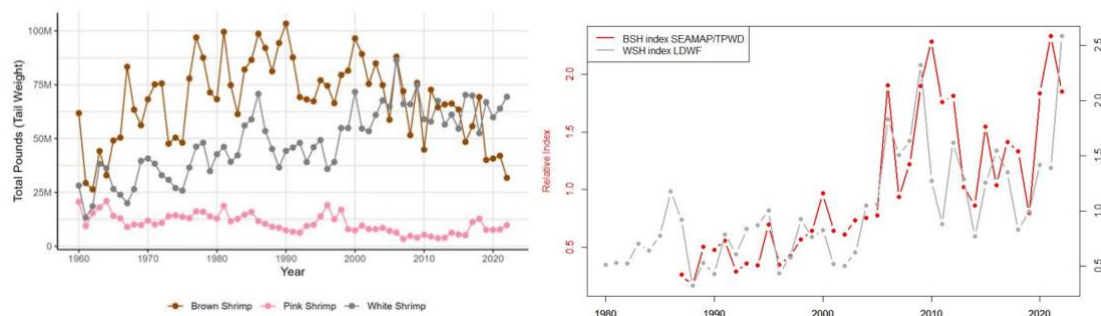


Figure 3. Commercial landings (left) of brown, pink and white shrimp and VAST-derived indices of abundance (right) of brown and white shrimp.

Irrespective of whether environmental drivers can be determined, the JABBA modelling framework is not capable of incorporating such drivers into its production function, rather it must assume stationarity, which as discussed above, is highly unlikely. This produces a conundrum for fitting data with JABBA. Use a long timeseries with greater contrast or limit it to contemporary years to ensure the model reflects recent environmental and/or productivity conditions (as these are more likely to be similar to those in the future). Building environmental drivers into state-space SPM has been successfully done for a short lived highly dynamic species, the blue swimmer crab (Marks et al., 2021).

It is likely that these same issues exist in the GP-EDM modelling framework. This model uses historical experience to project future states, which requires the modelled timeseries to have experienced similar conditions to current and to know how these will change into the future. With a unidirectional trend occurring in water temperature, sea levels and hurricane intensity, it seems unlikely that, within the timeframe of available data, this experience exists. As such its ability to forecast shrimp biomass into the future when the climate is changing in a unidirectional fashion and new conditions are being experienced, appears limited. Estimates of MSY which are developed by GP-EDM are thus likely to be appropriate in the short term but will need to be re-estimated as the climate continues to evolve.

Irrespective of the non-stationarity of shrimp MSY in response to climate change, the history of relative shrimp biomass displays large interannual variations in productivity, indicating MSY would vary markedly between successive years. This phenomenon is displayed in the composite assessment figures of B/B_{msy} from the best models produced by the assessment team during the review workshop (Figure 4). Both species of shrimp show rapid cyclic behaviour between years of good and bad productivity, with some cases indicating an over-fished status in some years, followed by a “sustainable” level the following year. This behaviour highlights that the use of sustainability management reference levels associated with stationary MSY (B/B_{msy} and F/F_{msy}) are possibly not the most appropriate for such species. More dynamic reference points that can link to, and change with, annual variation in shrimp productivity (e.g., variable MSY or harvest rates) may be more appropriate.

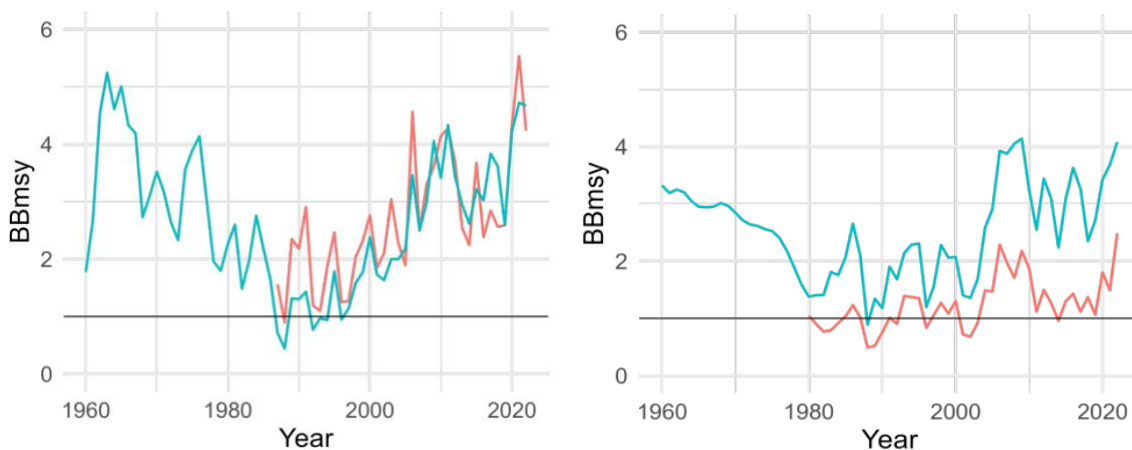


Figure 4. Model composite plots for brown (left) and white (right) shrimp with GP-EDM and JABBA estimates shown in orange and blue, respectively.

5. Provide, or comment on, recommendations to improve the assessment

- (i) Consider the research recommendations provided by the Data and Assessment processes in the context of overall improvement to the assessment, and make any additional research recommendations warranted.

The SEDAR workshop report SECTION IV: Research Recommendations outlines research recommendations stemming from the data and assessment workshops conducted as part of the Bench-Mark Assessment process (Appendix 6). These recommendations are all valid, however a prioritization process should be conducted to determine which are the most valuable and thus should be worked on first. To support the prioritization process, projects considered most likely to have a significant impact to subsequent shrimp stock assessments in the GOA are listed below:

- Improve effort data collection for inshore shrimping trips.
- Continue investigations into estimation of species-specific effort – vital if fishery-dependent data can be utilized as an abundance index.
- Updated life history information – useful to determine how size classes link with each other within the model framework
- Population connectivity models for brown and white shrimp – valuable for identifying important source locations and therefore possible drivers in productivity. Elemental composition of hepatopancreas/exoskeleton/tail meat has been shown to be an effective investigation tool.
- Exploration of indices of abundance utilizing combined data from AL, MS, and LA 16 ft state sampling programs, including potentially including a weighting factor to account for differences in area sampled (surface area, habitat area, etc.) – likely to lead to an additional measure of abundance.
- For the GP-EDM model creating a feedback loop that appropriately represents the removal of larger shrimp that may not contribute to future generations as well as the removal of smaller shrimp that may not grow into large shrimp should be accounted for. – making the model more biologically realistic.
- Direct inclusion of covariates generally resulted in improved model fits and could likely improve forecasting efficiency for trends of abundance. – Covariates must be projected into the future to determine MSY, but this can be done in a conservative fashion. The use of most recent (and therefore likely) future climate covariates and conservative (worst case) economics forecasts ensures MSY estimation remains conservative.
- Implications of the LDWF survey capturing mostly small shrimp in conjunction with the fishery capturing mostly large shrimp should be investigated. – Every effort should be made to ensure that the index of abundance directly aligns with the commercial fishery.

In addition to the research recommendations prioritized above, additional recommendations arising from the review workshop that should be examined in conjunction with future shrimp stock assessments (i.e., as future research projects) are listed below:

- Trial indices of abundance based on weight/effort rather than numbers/effort in the modelling process.
- To examine linkages between the environment and shrimp productivity, analysis should be limited to a single cohort, identified through the examination of size-frequency histograms.
- Linkages between size cohorts and sample timing should be discussed with a shrimp biologist/examined with shrimp growth curves to determine the best alignment. A more realistic

production function may be, in the example of small shrimp, $B_{t+1}^M = B_t^S - C_t^S + P(B_t^S - C_t^S/2)$, where the biomass of medium shrimp is a product of small shrimp biomass in the previous timestep. Note the use of $1/2$ catch to approximate the average biomass in the timestep t rather than the biomass at the end of the timestep.

- Re-examine fishery dependent data for the pink shrimp. It should be noted that not all members of the fleet need to be utilized to construct a robust index, rather a subset of avid fishers with good bookkeeping processes will produce a much better index than an entire fleet with constantly changing dynamics and drivers.
- Commercial fishing landings should be linked to effort by individual vessels to provide a more direct data source for future assessments. A review of commercial catch and effort statistics and how these could be better recorded to produce valuable information should be conducted.
- If environmental links to productivity are determined (or if linking economics to the SPM model was deemed necessary) use a surplus production model developed in TMB to use its state-space capabilities. Such a model has been successfully developed for the short lived highly dynamic blue swimmer crab in Australia (Marks et al., 2021). This model can be implemented through the L4Assess r package available on GitHub (<https://github.com/SAlexhesp/L4Assess-RPackage>).
- Examine the relationship between timeseries length and model stability in GP-EDM. – use the brown shrimp dataset and progressively reduce the timeseries length and monitor model stability. This will provide valuable information, especially for the assessment of pink shrimp, for which the current timeseries appears too short.
- Determine how well GP-EDM models can be used to estimate MSY reference points if data were collected while the stock was not near B_{msy} or K . Is it possible to estimate these parameters using this process in a lightly or chronically overfished stock? That is, can models be extrapolated into unsampled areas of the data space?
- Examine a month-year interaction in VAST models containing monthly data to account for the possibility of a change in monthly contribution over time. This is especially relevant for brown shrimp for which the pattern of commercial exploitation has changed markedly.

(ii) If applicable, provide recommendations for improvement or for addressing any inadequacies identified in the data or assessment modeling. These recommendations should be described in sufficient detail for application, and should be practical for short-term implementation (e.g., achievable within ~6 months). Longer-term recommendations should instead be listed as research recommendations above.

The assessment modelling discussed during the review workshop has been clearly outlined and well developed though previous workshops. The assessment was very thorough and appropriately applied to the problem at hand. It would however benefit from the incorporation of the recommendations listed below which are discussed in greater detail under the above TORs:

- Examine estimating the missed SEAMAP sample in 2020 (due to covid) based on a relationship between shrimp abundance in summer and the subsequent fall rather than adjacent summer samples (e.g., 2019 and 2021).
- Examine removing day trawls from any dataset containing both day and night trawls. This also applies to any sampling locations that consistently recorded no shrimp – their removal from the dataset will reduce the proportion of zeros in the data and result in a more precise standardized index of abundance.

- Do not use timeseries averages for the first year's lagged indices of environment when examining links with productivity. Rather a better process would be to shorten the timeseries by two years to allow for only observed data to be used in the model.
- A sensitivity analysis should be conducted using the final model versions (JABBA and EDM) in which landings are perturbed to understand the sensitivity of benchmarks to this input.

6. Provide recommendations on possible ways to improve the Bench-Mark Assessment process.

The current Bench-Mark assessment was conducted in a very logical and systematic manner and should be considered best practice. Possible improvements include:

- An infographic (containing flow diagrams) should be developed that clearly shows what data is used and how these evolve throughout the Bench-Mark Assessment process including the link between VAST and JABBA on one limb and on another limb the link between GP and EDM. – this will aid in dissemination of the process and outcomes (assessment) especially with industry stakeholders.
- A shrimp biologist or scientist with a thorough understanding of shrimp biology should be added to the assessment team to ensure the linkages between age/size cohorts and spatial emigration patterns are appropriately built into the modelling process.
- Improve the access for the AS to all databases (e.g., SEAMAP, TPWG, LDWF).
- Model code (e.g., R code) providing the exact modelling process as conducted by the AS should, in future, be provided to assessment reviewers. This would facilitate their understanding of the modelling processes conducted and allow them to examine the implications of many of their queries without having to request additional runs by the AS.

7. Prepare a Review Workshop Summary Report describing the Panel's evaluation of the Research Track stock assessment and addressing each Term of Reference.

The review panel started to develop a Review Workshop Summary Report on the fourth day of the review workshop. The panel reconvened on the final day to review panel members' sub-sections of the report and determine the process needed to finalize the report. The chair (Jim Tolan) proceeded to modify the report with the aim to provide it back to the review panel over the subsequent weeks before its submission three weeks from the end of the workshop.

8. Brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

The review panel proceedings consisted of a five-day workshop from the 23rd to 27th of June 2025. The collaborative nature of this process was very positive and resulted in a pleasant working environment, where ideas and thoughts were discussed freely.

23 June 2025.

The meeting was held at the Gulf Council Office (Tampa Florida) at 1 pm and was attended by the five reviewers, a panel chair and three assessment scientists, plus five staff and one industry member (Appendix 4). The day's meeting finished at 6pm.

Presentations were provided to the panel as outlined in the meeting agenda (Appendix 5) in an informal setting allowing for clarifications and discussions on key points to occur

throughout the presentations. The meeting was conducted as a webinar to allow other people to watch but not be involved. The meeting was also recorded.

Key presentation points included:

- Data collections and structure
- Brown shrimp index development using VAST
- Brown shrimp assessment using JABBA.

Key discussion points included:

- Scaling of biomass in the JABBA model
- The influence of fixing “m” (shape parameter) in JABBA
- Reality of biomass estimates produced by JABBA

24 June 2025.

The meeting started at 8:30 am and was attended by the five reviewers, a panel chair and three assessment scientists, five staff and one industry member (Appendix 4). The meeting finished at 6 pm. The meeting was conducted as a webinar to allow other people to watch but not be involved. The meeting was also recorded.

Key presentation points were:

- EDM development, structure and assumptions
- Brown shrimp assessment using EDM
- Production of information requested by reviewers
- White shrimp index development using VAST
- White shrimp assessment using JABBA
- White shrimp assessment using EDM.
- Pink shrimp index development using VAST
- Pink shrimp assessment using JABBA
- Pink shrimp assessment using EDM.

Key discussion points were:

- Reality of brown shrimp MSY estimates produced by the EDM analysis
- An estimate of swept-area biomass determined by the AS was substantially below model estimated biomass. Suggested the trawls nets have a catchability of ~7% which appears low. The Swept-area biomass estimate contains numerous assumptions which could bias this markedly and the RP considered further examination of this to be unnecessary.

25 June 2025.

The meeting started at 8:30 am and was attended by the five reviewers, a panel chair and three assessment scientists, five staff and one industry member (Appendix 4). The meeting

finished at 6 pm and was focused on discussions of the information provided over the previous two days and new analysis that had been conducted at the request of the RP. The meeting was conducted as a webinar to allow other people to watch but not be involved. The meeting was also recorded.

Key presentation points were:

- Sensitivity runs examining the influence of fixing “ m ” (shape parameter) in JABBA.
- Comparison between SEAMAP and TPWG trawl indices.

Key discussion points were:

- The shape parameter in the JABBA model (m) had a marked impact on model fit and diagnostics. Reducing the prior on this parameter resulted in a better model fit and has been adopted by the AS for future models.
- Smaller values of the m prior scales population size upwards and B/BMSY increases, especially for white and pink shrimp. The sensitivity of JABBA to this parameter reduces confidence in model outputs.
- Model estimates of MSY were the same for brown shrimp irrespective of the m prior. Provides increased confidence in the model estimate of ~80- 90 million pounds of brown shrimp.
- Using trends in catch rate to manage fishery, moving up or down relative to a point (historical) considered robust, especially in GOA shrimp fisheries where landings are relatively low due to economic constraints.
- To share information with industry, show general trends in catch rates and how they match between indices, raw to standardised, to biomass estimates from JABBA and EDM.
- Similarity of VAST indices for brown and white shrimp, indicating that the productivity of both stocks was being driven by a similar variable and commercial fishing was having very little impact.
- Progressively shortening the length of the brown shrimp timeseries in GP-EDM to determine minimum length of time series required for this modelling process.

26 June 2025.

The meeting started at 10:30 am and was attended by the five reviewers, a panel chair and three assessment scientists, five staff and one industry member (Appendix 4). The meeting finished at 4:30 pm and was focused on continued discussions of the information provided over the first two days and subsequent analysis requested by the RP. The meeting was conducted as a webinar to allow other people to watch but not be involved. The meeting was also recorded.

Key presentation points were:

- Model outputs (e.g. biomass trends) combined onto the one figure for each species across models. Figures showed similar trends when overlaid which was positive and a good format to show industry stakeholders.

Key discussion points were:

- Adding landings to the combined model output figures provides a more complete picture.
- VAST detected no month effect for pink shrimp, suggesting the commercial fishery was having little impact on the stock between the surveys.
- The pink shrimp modelling could be spatially split into two different zones, to improve the response in the survey data to commercial fishing.
- The brown shrimp assessment could also be examined on a finer spatial scale. Also try limiting index data to night-time SEAMAP and day-time TPWG combined via VAST.
- Can fishery-dependent data be used for pink shrimp. Is very complex to develop a robust index from commercial data. Need to identify what would make it a viable index that would result in a decent measure. Need to account for fishing efficiency and behavioural changes due to economics.
- The GP-EDM modelling process appears to consistently outperform JABBA. Is this partly due to shrimp productivity being chaotic and not following a production curve as defined by a surplus production model?
- Shrimp fishers are resilient; they can be driven low under a scenario of heavy fishing and environment, but they can then bounce back fast.

27 June 2025.

The meeting started at 9 am and was attended by the five reviewers, a panel chair and three assessment scientists, five staff and one industry member (Appendix 4). The meeting finished at 10 am and was focused on the group report being compiled by the panel chair. The meeting was conducted as a webinar to allow other people to watch but not be involved. The meeting was also recorded.

Key discussion points were:

- The report was in a good stage of development and the chair would provide it back to the panel to modify once he had finished pulling it together from the panel's inputs.
- Development of an infographic for the GP-EDM process would be extremely valuable for educating industry stakeholders of the process and removing some of the suspicion produced by being uninformed.
- Most of the review discussions over the first four days was based on the modelling approach, with little time actually discussing the status of the stocks.

The consensus was that the assessments indicated that the shrimp were being fished sustainably.

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Appendix 1: Bibliography of materials provided for review

Documents (pdf and word):

- SEDAR87-DW-01 Estimation of Commercial Shrimp Effort in the Gulf of Mexico Kyle Dettloff 30 August 2023
- SEDAR87-DW-02 Social Dimensions of the Gulf of Mexico Shrimp Fishery: Overview
- SEDAR87-DW-03 Commercial Landings of Gulf of Mexico Shrimp Self-Reported Survey 2005-2020
- SEDAR87-DW-04 Vessel and Gear Characterizations of Gulf of Mexico Shrimp Self-Reported Survey 2005-2020
- SEDAR87-DW-05 Gulf of Mexico Brown, Pink, and White Shrimp Weight-Length Regression using SEAMAP Data
- SEDAR87-DW-06 Commercial Shrimp Landings of Gulf of Mexico Final Title: Gulf of Mexico Commercial Brown, Pink and White Shrimp Landings
- SEDAR87-DW-07 Economics of the Federal Gulf of Mexico Shrimp Fishery
- SEDAR87-DW-08 General Economic Measures for Fuel Price Trend, Inflation Adjustment, and Discounting
- SEDAR87-DW-09 Gulf of Mexico Spatial-Temporal Environmental Data
- SEDAR87-DW-10 Shrimp Import Data
- SEDAR87-DW-11 Indices of relative abundance for Pink Shrimp, and summary of data availability for Pink, Brown, and White Shrimp, from inshore surveys of Florida's Gulf coast estuaries
- SEDAR87-DW-12 Inshore brown and white shrimp relative abundance in Louisiana
- SEDAR87-DW-13 Brown, White and Pink Shrimp Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico
- SEDAR87-DW-14 Summary of the Gulf of Mexico Shrimp Effort Data Collection
- SEDAR87-DW-15 Social Dimensions of Gulf of Mexico Shrimping
- SEDAR87-DW-16 SEDAR 87 Commercial Fishery Landings and Effort Figures for White, Pink, and Brown Shrimp in the US Gulf of Mexico, 1960–2021
- SEDAR87-AP-01 Development of estuarine environmental indices for SEDAR 87 Gulf of Mexico White, Pink, and brown shrimp stock assessment
- SEDAR87-AP-02 Price Indices for Shrimp Imports and Gulf of Mexico Shrimp Landings by Size and Season
- SEDAR87-AP-03 Developing a fishery-independent index of relative abundance for Gulf of Mexico Brown Shrimp using VAST
- SEDAR87-AP-04 Developing a fishery-independent index of relative abundance for Gulf of Mexico Pink Shrimp using VAST
- SEDAR87-AP-05 Developing a fishery-independent index of relative abundance for Gulf of Mexico White Shrimp using VAST
- SEDAR87-RW-01 State Management History
- SEDAR87-RW-02 State Management History
- SEDAR87-RW-03 State Management History
- SEDAR87-RW-04 State Management History
- SEDAR87-RW-05 State Management History
- SEDAR87-SAR1 Gulf Council White Shrimp
- SEDAR87-SAR2 Gulf Council Pink Shrimp

SEDAR87-SAR3 Gulf Council Brown Shrimp
SEDAR87-RD01 SEAMAP Trawl Shrimp Data and Index Estimation Work Group Report
SEDAR87-RD02 The Annual Economic Survey of Federal Gulf Shrimp Permit Holders:
Implementation and Descriptive Results for 2008
SEDAR87-RD03 Mississippi Department of Marine Resources and University of Southern
Mississippi Gulf Coast Research Laboratory Inshore Trawl Monitoring Programs:
Sampling and Lab Protocols
SEDAR87-RD04 Marine Fisheries Crustacean Section - Independent Sampling Activities:
Field Manual Louisiana Wildlife and Fisheries
SEDAR87-RD05 Fisheries Assessment and Monitoring Program (FAMP) Alabama
Marine Resources Division
SEDAR87-RD06 AL FAMP Assessment Sampling - Standard Operating Procedures
Alabama Marine Resources Division
SEDAR87-RD07 TPWD's Gulf Trawl Sample Design Texas Parks and Wildlife Division
SEDAR87-RD08 Commercial brown, white, and pink shrimp tail size: total size
conversions
SEDAR87-RD09 Final Report: U.S. Gulf of Mexico Commercial Shrimp Conversion
Factors Validation 2020 GSMFC
SEDAR87-RD10 Conversion of "whole" and "headless" weights in commercial Gulf of
Mexico shrimps
SEDAR87-RD11 Brown, White and Pink Shrimp Life History Summaries
SEDAR87-RD12 JABBA: Just Another Bayesian Biomass Assessment
SEDAR87-RD13 Empirical dynamic modeling for sustainable benchmarks of short-lived
species
SEDAR87-RD14 Recent developments in empirical dynamic modelling
SEDAR87-RD15 Comparing estimates of abundance trends and distribution shifts using
single- and multispecies models of fishes and biogenic habitat
SEDAR87-RD16 The Texas Shrimp Fishery Texas Parks and Wildlife

Presentations (ppt files):

- <https://sedarweb.org/documents/sedar-87-review-workshop-gulf-brown-white-and-pink-shrimp-introduction-presentation/>

Appendix 2: Terms of reference from the Data and Assessment processes.

Data Workshop Terms of Reference

1. Gather data through 2022 (where possible) for Gulf of Mexico White, Pink, and Brown shrimp.
2. Review, discuss, and tabulate available life history information for each stock being assessed.
 - Evaluate growth data where available. Determine the adequacy of available life history information for different types of assessment or population model
 - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source.
3. Create a conceptual model based on feedback from a variety of industry representatives in the Data Workshop to capture their institutional knowledge.
4. Provide measures of population abundance that are appropriate for stock assessment.
 - Consider all available and relevant fishery-dependent and -independent data sources
 - Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
 - Provide maps of fishery and independent survey coverage, where possible.
 - Develop fishery and survey CPUE indices by appropriate strata (e.g., area) and include measures of precision and accuracy.
 - Provide appropriate measures of uncertainty for the abundance indices to be used in stock assessment models.
 - Document pros and cons of available indices regarding their ability to represent abundance.
 - For recommended indices, document any known or suspected temporal patterns in catchability not accounted for by standardization.
 - Provide appropriate measures of uncertainty for the abundance indices.
5. Provide commercial catch statistics for each stock where possible. Document species-specific issues.
 - Provide maps of fishery effort and harvest by sector and/or gear by species, where possible.
 - Provide estimates of uncertainty around each set of landings and effort estimates.
6. Describe any known evidence regarding ecosystem, climate, species interactions, habitat considerations, species range modifications and/or episodic events that would reasonably be expected to affect shrimp population dynamics, and the effectiveness of reference points.
 - Provide species envelopes, i.e. minimum and maximum values of environmental boundaries (e.g. depth, temperature, substrate, relief) based on observations of occurrence.
 - Develop hypotheses to link the ecosystem and climatic events identified in addressing this TOR to population and fishery parameters that can be evaluated and modeled.
7. Integrate economists into the stock assessment model development process in order to

explore models that can address questions such as benefits of seasonal/spatial closures, impacts of fuel prices on total effort, and ex-vessel prices of different market categories, if possible.

- Detail the early 2000 industry consolidation and impacts of ex-vessel price on effort

8. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment.

9. Prepare a Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines.

Assessment Terms of Reference

1. Review any changes in data or analyses following the Data Workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

2. Develop a management advice framework. Consider data availability (e.g., landings and CPUE) and management needs (e.g., harvest controls, stock status), and particular needs of the fishery and the biology of the resource.

3. Examine the impacts of social science factors on biological reference points as informed by stakeholders through industry input.

4. Recommend biological reference points for use in management

- Consider how reference points could be affected by management, ecosystem, climate, species interactions, habitat considerations, social or economic drivers, and/or episodic events.

5. Provide estimates of stock population parameters, including: Fishing mortality, biomass, selectivity, and/or other parameters as necessary to describe the population.

6. Characterize uncertainty in the assessment and estimated values.

- Consider uncertainty in input data, modeling approach, and model configuration.
- Provide appropriate measures of model performance, reliability, and ‘goodness of fit’.
- Provide measures of uncertainty for estimated parameters and derived quantities such as biological reference points and stock status if feasible.

7. Provide recommendations for future research and data collection. Emphasize items that will improve future assessment capabilities and reliability. Consider data, monitoring, and assessment needs.

8. Complete an Assessment Workshop Report in accordance with project schedule deadlines.

Appendix 3: A copy of this Statement of Work

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Fisheries
Center for Independent Experts (CIE) Program
External Independent Peer Review

SEDAR 87 Gulf of Mexico White, Pink, and Brown Shrimp
June 23-27, 2025

Background

The NOAA Fisheries is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NOAA Fisheries science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards¹.

Scope

The **SouthEast Data, Assessment, and Review (SEDAR)** is the cooperative process by which stock assessment projects are conducted in NOAA Fisheries' Southeast Region. SEDAR was initiated to improve planning and coordination of stock assessment activities and to improve the quality and reliability of assessments.

The SEDAR 87 review workshop will be a CIE assessment review of the Benchmark Assessment of Gulf of Mexico white, pink, and brown shrimp. The review workshop provides an independent peer review of SEDAR stock assessments. The term review is applied broadly, as the review panel may request additional analyses, error corrections and additional runs of the assessment models provided by the assessment panel. The review panel is ultimately responsible for providing advice to ensure the assessment is appropriate for use by fishery managers.

The specified format and contents of the individual peer review reports are found in **Annex 1**. The Terms of Reference (ToR) of the peer review are listed in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements

¹ https://www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/memoranda/2005/m05-03.pdf

NOAA Fisheries requires three reviewers to conduct an impartial and independent peer review in accordance with the Performance Work Statement (PWS), OMB guidelines, and the ToRs below. The reviewers shall have a working knowledge in stock assessment, statistics, and fisheries science sufficient to complete the primary task of providing peer-review advice in compliance with the workshop Terms of Reference fisheries stock assessment. Expertise in the usage of at least two of the three of the following: surplus production models, EDM (Empirical Dynamic Modeling), and VAST (Vector Autoregressive Spatio-Temporal Model) modeling approaches and the associated diagnostics is necessary.

The chair, who is in addition to the three reviewers, will not be provided by the CIE. Although the chair will be participating in this review, the chair's participation (e.g., labor and travel) is not covered by this contract. Each reviewer will write an individual review report in accordance with the PWS, OMB Guidelines, and the TORs below. Modifications to the PWS and TORs cannot be made during the peer review, and any PWS or TORs modifications prior to the peer review shall be approved by the Contracting Officer's Representative (COR) and the CIE contractor. All TORs must be addressed in each reviewer's report.

Tasks for Reviewers

- 1) Pre-review Background Documents: Review the following background materials and reports prior to the review:

Completed Data and Assessment reports, along with all working papers and reference documents, will be available on the SEDAR website no later than two weeks prior to the in-person review workshop:

<https://sedarweb.org/assessments/sedar-87-gulf-of-mexico-white-pink-and-brown-shrimp/>

- 2) Attend and participate in an in-person review meeting. The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to answer any questions from the reviewers, and to provide any additional information required by the reviewers.
- 3) After the review meeting, reviewers shall conduct an independent peer review report in accordance with the requirements specified in this PWS, OMB guidelines, and ToRs, in adherence with the required formatting and content guidelines. Reviewers are not required to reach a consensus.
- 4) Each reviewer shall assist the Chair of the meeting with contributions to the summary report.
- 5) Deliver their reports to the Government according to the specified milestones dates.

Foreign National Security Clearance

Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days in advance. For additional information, please see the following link:

<https://www.commerce.gov/osy/programs/foreign-access-management>. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be Tampa, Florida

Period of Performance

The period of performance shall be from the time of award through August 15, 2025. Each reviewer’s duties shall not exceed **14** days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Schedule	Milestones and Deliverables
Within 2 weeks of award	Contractor selects and confirms reviewers
Approximately 2 weeks prior to the review	Contractor provides the pre-review documents to the reviewers
June 23-27, 2025	Panel review meeting
Approximately 2 weeks later	Contractor receives draft reports
Within 3 weeks of receiving draft reports	Contractor submits final reports to the Government

* The Peer Review Summary Report will not be submitted to, reviewed, or approved by the Contractor.

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each ToR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Confidentiality and Data Privacy

This contract may require that services contractors have access to Privacy Information. Services contractors are responsible for maintaining the confidentiality of all subjects and materials and may be required to sign and adhere to a Non-disclosure Agreement (NDA).

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations ([Travel resources | GSA](#)), and all contractor travel must be approved by the COR prior to the actual travel. Any travel conducted prior to the receipt of proper written authorization from the COR will be done at the Contractor’s own risk and expense. International travel is authorized for this contract. Travel is not to exceed \$12,000.00.

Project Contacts

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Annex 1: Peer Review Report Requirements

1. The independent Peer Reviewer report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).
2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each ToR, in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs.
 - a. Reviewers must describe in their own words the review activities completed during the panel review meeting, including a brief summary of findings, of the science, conclusions, and recommendations.
 - b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, but especially where there were divergent views.
 - c. Reviewers should elaborate on any points raised in the summary report that they believe might require further clarification.
 - d. Reviewers shall provide a critique of the agency review process, including suggestions for improvements of both process and products.
 - e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each ToR, and shall not simply repeat the contents of the summary report.
3. The report shall include the following appendices:
 - Appendix 1: Bibliography of materials provided for review
 - Appendix 2: A copy of this Performance Work Statement
 - Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review

SEDAR 87 Gulf of Mexico White, Pink, and Brown Shrimp
June 23-27, 2025

Review Workshop Terms of Reference

1. Evaluate the degree to which the terms of reference from the Data and Assessment processes were addressed.
2. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions. Consider the following:
 - Are data decisions made by the Data and Assessment processes justified?
 - Are data uncertainties acknowledged, reported, and within normal or expected levels?
 - Is the appropriate model(s) applied properly to the available data?
 - Are input data series sufficient to support the assessment approach?
3. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, given the available data. Consider the following:
 - Are methods scientifically sound and robust?
 - Are priority modeling issues clearly stated and addressed?
 - Are the methods appropriate for the available data?
 - Are assessment models configured properly and used in a manner consistent with standard practices?
4. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
 - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
 - Comment on the likely relationship of this variability with possible ecosystem or climate factors and possible mechanisms for including this into management reference points.
5. Provide, or comment on, recommendations to improve the assessment
 - Consider the research recommendations provided by the Data and Assessment processes in the context of overall improvement to the assessment, and make any additional research recommendations warranted.
 - If applicable, provide recommendations for improvement or for addressing any inadequacies identified in the data or assessment modeling. These recommendations should be described in sufficient detail for application, and should be practical for short-term implementation (e.g., achievable within ~6 months). Longer-term recommendations should instead be listed as research recommendations above.
6. Provide recommendations on possible ways to improve the Research Track Assessment process.

7. Prepare a Review Workshop Summary Report describing the Panel's evaluation of the Research Track stock assessment and addressing each Term of Reference.

Annex 3: Tentative Agenda

SEDAR 87 Gulf of Mexico White, Pink, and Brown Shrimp Review

June 23 – 27, 2024

Tampa, Florida

Monday

1:00 pm – 6:00 pm	Introductions and Opening Remarks Coordinator <i>- Agenda Review, TOR, Task Assignments</i> Assessment Presentations	Analytic
Team	<i>- Background</i> <i>- Assessment Data & Methods</i>	

Tuesday

9:00 am – 12:00 pm	Assessment Presentations (continued)	Analytic
Team	<i>- Assessment Data & Methods</i>	
12:00 pm – 1:30 pm	Lunch Break	
1:30 pm – 4:30 pm	Assessment Presentations (continued)	Analytic
Team	<i>- Assessment Data & Methods</i> <i>- Identify additional analyses, sensitivities, corrections</i>	
4:30 pm – 5:00 pm	Wrap Up/Public Comment	Chair
5:00 pm - 6:00 pm	Panel Work Session	Chair

Tuesday Goals: Initial assessment presentations completed, sensitivities and modifications identified.

Wednesday

8:30 a.m. – 11:30 pm	Assessment Presentations (continued)	Analytic
Team	<i>- Assessment Methods</i> <i>- Identify additional analyses, sensitivities, corrections</i>	
11:30 a.m. – 1:00 pm	Lunch Break	
1:00 pm – 5:30 pm	Panel Discussion	Chair
	<i>- Review additional analyses, sensitivities</i> <i>- Recommendations and comments</i>	
5:30 pm - 6:00 pm	Public Comment	Chair

Wednesday Goals: Presentations completed, additional sensitivities identified, preferred models selected, projection approaches approved, Summary report drafts begun.

Thursday

8:30 a.m. – 11:30 pm	Panel Discussion	Chair
	<i>- Review additional analyses, sensitivities</i> <i>- Recommendations and comments</i>	
11:30 a.m. – 1:00 pm	Lunch Break	
1:00 pm – 5:30 pm	Panel Discussion	Chair
	<i>- Final sensitivities reviewed.</i> <i>- Projections reviewed.</i>	
5:30 pm - 6:00 pm	Public Comment	Chair

Thursday Goals: Review final sensitivities, complete assessment work, and finalize discussions.

Friday

9:00 a.m. – 1:00 pm

Panel Discussion or Work Session
- Review Summary Reports

Chair

Friday Goals: Final results available. Draft Summary Report reviewed.

Appendix 4: Panel membership or other pertinent information from the panel review meeting.

Key Personnel:

Roberto Koeneke Assistant Coordinator RKoeneke@ntvifederal.com
Center for Independent Experts (CIE)
NTVI Solutions, LLC

Manoj Shivilani Lead Coordinator Mshivilani@ntvifederal.com
N Center for Independent Experts (CIE)
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Review Panel

Jim Tolan (Chair)	GMFMC Appointee	jimtolantpwd@gmail.com
Simon de Lestang	CIE Reviewer	s.delestang@gmail.com
Larry Jacobson	CIE Reviewer	LarryJacobson6@gmail.com
Erik Lang	LDWF/GMFMC Appointee	elang@wlf.la.gov
Joe Powers	CIE Reviewer	j.powers.fish@gmail.com
Steven Saul	GMFMC SSC	Steven.Saul@asu.edu

Analytic Team

Lisa Ailloud	NMFS SEFSC	lisa.ailloud@noaa.gov
Molly Stevens	NMFS SEFSC	molly.stevens@noaa.gov
Katie Siegfried	NMFS SEFSC	kate.siegfried@noaa.gov

Appointed Observers

Fernando Martinez-Andrade TXPWD

Staff

Julie A Neer	SEDAR
Matt Freeman	GMFMC Staff
John Froeschke	GMFMC Staff
Ryan Rindone	GMFMC Staff
Charlotte Schiaffo	GMFMC Staff

Workshop Observers

Leann Bosarge Shrimp Industry

Workshop Observers via Webinar

Jason Adriance	LADWF
Jesse Buntin	NOAA
Peyton Cagle	LADWF
Judd Curtis	SAFMC Staff
Tricia Kimball	
Dominique Lazarre	SERO
Richard Malinowski	NOAA
Jessica Marchant	AL DCNR
Michelle Masi	SERO
Steve Munch	SWFSC
Emily Ott	SEDAR
Jason Saucier	MS DMR
Rebecca Smith	NOAA
John Walter	SEFSC

Appendix 5: Meeting agenda from the panel review meeting.



SEDAR

SouthEast Data, Assessment, and Review

4055 Faber Place Drive, Suite 201, North Charleston, SC 29405

Phone: (843) 571-4366 Fax: (843) 769-4520 SEDARweb.org

SEDAR 87 Gulf of Mexico White, Pink, and Brown Shrimp Review Workshop June 23 – 27, 2025

Monday

1:00 pm – 6:00 pm	Introductions and Opening Remarks <i>- Agenda Review, TOR, Task Assignments</i>	Coordinator
	Assessment Presentations <i>- Background</i> <i>- Assessment Data & Methods</i>	Analytic Team

Tuesday

8:30 am – 12:00 pm	Assessment Presentations (continued) <i>- Assessment Data & Methods</i>	Analytic Team
12:00 pm – 1:30 pm	Lunch Break	
1:30 pm – 4:30 pm	Assessment Presentations (continued) <i>- Assessment Data & Methods</i> <i>- Identify additional analyses, sensitivities, corrections</i>	Analytic Team
4:30 pm – 5:00 pm	Wrap Up/Public Comment	Chair
5:00 pm - 6:00 pm	Panel Work Session	Chair

Tuesday Goals: Initial assessment presentations completed, sensitivities and modifications identified.

Wednesday

8:30 a.m. – 11:30 pm	Assessment Presentations (continued) <i>- Assessment Methods</i> <i>- Identify additional analyses, sensitivities, corrections</i>	Analytic Team
11:30 a.m. – 1:00 pm	Lunch Break	
1:00 pm – 5:30 pm	Panel Discussion <i>- Review additional analyses, sensitivities</i> <i>- Recommendations and comments</i>	Chair
5:30 pm - 6:00 pm	Public Comment	Chair

Wednesday Goals: Presentations completed, additional sensitivities identified, preferred models selected, projection approaches approved, Summary report drafts begun.

Thursday

8:30 a.m. – 11:30 pm	Panel Discussion <i>- Review additional analyses, sensitivities</i> <i>- Recommendations and comments</i>	Chair
11:30 a.m. – 1:00 pm	Lunch Break	
1:00 pm – 5:30 pm	Panel Discussion <i>- Final sensitivities reviewed.</i> <i>- Projections reviewed.</i>	Chair

5:30 pm - 6:00 pm	Public Comment	Chair
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Thursday Goals: Review final sensitivities, complete assessment work, and finalize discussions.

Friday

8:30 a.m. – 1:00 pm	Panel Discussion or Work Session <i>- Review Summary Reports</i>	Chair
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Friday Goals: Final results available. Draft Summary Report reviewed.

Appendix 6: Research Recommendations developed during previous workshops.

DATA WORKSHOP RESEARCH RECOMMENDATIONS

COMMERCIAL FISHERY STATISTICS RESEARCH RECOMMENDATIONS

- Continue investigations into the methodology of the GSS to better understand differences between GSS and STT programs where they overlap.
- Improve effort data collection for inshore shrimping trips.
- Develop a method to quantify under-reporting of landings in the shrimp fishery, perhaps through the use of separate socio-economic surveys.
- Quantify the prevalence of misidentification of “hopper” brown shrimp within each Gulf state.
- Continue investigations into estimation of species-specific effort.

ENVIRONMENTAL DRIVERS/INDUSTRY REPORT RESEARCH RECOMMENDATIONS

We highlight data gaps and research recommendations that will improve understanding of environmental impacts on shrimp.

Updated life history information – Much of the life history obtained for shrimp was conducted in the 1960-1970s. Given the short generation time of shrimp, high environmental influence on productivity, and nonstationary environmental dynamics, life history dynamics have likely changed, and these parameters should be updated (e.g., SEDAR87-DW-05).

Density dependence - The suggestion to prioritize environmental impacts on the estuarine stages of shrimp relies on the assumption that this is the region in which density dependence occurs. Expert guidance has suggested that there is no relationship between post larvae entering the estuary and the number of spawning adults in the population (J Nance). While previous efforts suggest that density dependence occurs during estuary residence (e.g., Galveston Bay sub-adult survey to predict brown fishery dynamics for the upcoming year), further research to support this assumption would further validate the assumptions made herein.

Population connectivity models for brown and white shrimp – Research linking spawning adults to their nursery estuary may provide guidance on which estuarine habitats are most productive. Priority could then be given to these most influential nursery habitats for research and conservation.

Mechanistic environmental relationships – Hypothesized environmental drivers presented in this report are correlative only and do not attempt to identify the mechanistic relationship underlying these correlations. Further research identifying the exact driver and the organismal and stock-wide response to these drivers would improve this effort. Updated environmental relationships should be generated or explored.

State FIM data standardization - Additional research should be conducted to standardize and calibrate state-by-state surveys.

Role of shrimp as key forage species - As forage species, shrimp play a key role in the ecosystem.

Additional research may clarify linkages between shrimp and predator species and better clarify the extent of predator-induced mortality (e.g., Fujiwara et al. 2016). These linkages may inform how these interrelated species should be managed from an ecosystem-based perspective.

MEASURES OF POPULATION ABUNDANCE RESEARCH RECOMMENDATIONS

- Explore survey / gear calibration studies among state and federal sampling programs
- Perform post hoc analysis to potentially account for habitat classification variables and on indices of abundance
- Examination of whether due to zeros, indices based on monthly data may best be structured to focus on core recruitment months or accommodate in model
- Exploration of indices of abundance utilizing combined data from AL, MS, and LA 16 ft state sampling programs, including potentially including a weighting factor to account for differences in area sampled (surface area, habitat area, etc.)

ECONOMICS AND SOCIAL SCIENCES

No research recommendations were provided.

ASSESSMENT PROCESS RESEARCH RECOMMENDATIONS

White Shrimp

The models provided in this report are sufficient to provide management advice for the stock. However, should future research funding become available, we have provided suggestions below.

Potential improvements to the modeling framework include accounting for removal of shrimp as it pertains to harvest rates that are optimized at varying size classes. Creating a feedback loop that appropriately represents the removal of larger shrimp that may not contribute to future generations as well as the removal of smaller shrimp that may not grow into large shrimp should be accounted for. Sensitivities of these potential feedback loops and their impact on estimating optimal harvest rates should be investigated in both directions (i.e. Large to Small and Small to Large impacts).

Additional research into covariates may also be investigated. Direct inclusion of covariates generally resulted in improved model fits and could likely improve forecasting efficiency for trends of abundance. To forecast MSY, covariates would need to be projected into the future. For environmental covariates, the cyclical nature of these trends would need to be captured. For economic covariates, the relationship with projected harvest rates would need to be explicitly defined.

Implications of the LDWF survey capturing mostly small shrimp in conjunction with the fishery capturing mostly large shrimp should be investigated as it pertains to catchability estimation and resulting estimates of escapement. It is suspected that this was the primary driver for a large process variance in the model.

Pink Shrimp

Additional research into covariates should be investigated. Direct inclusion of covariates resulted in improved model fits and could likely improve forecasting efficiency for trends of abundance. To forecast MSY, covariates would need to be projected into the future. For environmental covariates, the cyclical nature of these trends would need to be captured. For economic covariates, the relationship with projected harvest rates would need to be explicitly defined.

Potential improvements to the modeling framework include accounting for removal of shrimp as it pertains to harvest rates that are optimized at varying size classes. Creating a feedback loop that appropriately represents the removal of larger shrimp that may not contribute to future generations as well as the removal of smaller shrimp that may not grow into large shrimp should be accounted for. Sensitivities of these potential feedback loops and their impact on estimating optimal harvest rates should be investigated in both directions (i.e. Large to Small and Small to Large impacts).

As funding for scientific surveys is becoming increasingly sparse, implications of using an average of 2019/21 for missing summer 2020 SEAMAP data and resulting effects on model diagnostics should be investigated. EDM performs best on continuous, long time

series of data, and quantifying implications of future gaps in survey data would be valuable.

Brown Shrimp

The models provided in this report are sufficient to provide management advice for the stock. However, should future research funding become available, we have provided suggestions below.

Potential improvements to the modeling framework include accounting for removal of shrimp as it pertains to harvest rates that are optimized at varying size classes. Creating a feedback loop that appropriately represents the removal of larger shrimp that may not contribute to future generations as well as the removal of smaller shrimp that may not grow into large shrimp should be accounted for. Sensitivities of these potential feedback loops and their impact on estimating optimal harvest rates should be investigated in both directions (i.e. Large to Small and Small to Large impacts).

Additional research into covariates may also be investigated. Direct inclusion of covariates generally resulted in improved model fits and could likely improve forecasting efficiency for trends of abundance. To forecast MSY, covariates would need to be projected into the future. For environmental covariates, the cyclical nature of these trends would need to be captured. For economic covariates, the relationship with projected harvest rates would need to be explicitly defined.

As funding for scientific surveys is becoming increasingly sparse, implications of using an average of 2019/21 for missing summer 2020 SEAMAP data and resulting effects on model diagnostics should be investigated. EDM performs best on continuous, long time series of data, and quantifying implications of future gaps in survey data would be valuable.