STAKEHOLDER WORKSHOP ON MANAGEMENT REFERENCE POINTS FOR GULF MENHADEN FISHERIES

HOSTED BY

GULF STATES MARINE FISHERIES COMMISSION

FACILITATED BY

DR. MICHAEL JONES

SEPTEMBER 12-13, 2023

THE UNIVERSITY OF SOUTHERN MISSISSIPPI - GULF PARK CAMPUS
LONG BEACH, MISSISSIPPI

Sept 22, 2023 **Pub No. 320**

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TABLE OF CONTENTS

STAKEHOLDER WORKSHOP ON MANAGEMENT REFERENCE POINTS FOR GULF MENHADEN FISHERIES

September 12-13, 2023
Long Beach, MS

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Welcome and Introductions

Donaldson, the Executive Director of GSMFC, welcomed everyone to Mississippi and the 3rd, and hopefully final, workshop for developing reference points for Gulf Menhaden management. **VanderKooy** provided some facility housekeeping notes and reminded all attendees were considered participants and encouraged to ask questions and contribute to the two-day discussion. The workshop is not available online. A summary publication will be made available on the GSMFC website. **VanderKooy** welcomed Jones who lead this final installment after facilitating the previous two stakeholder workshops in 2019. **Jones** is a retired professor from Michigan State University who codirected the Quantitative Fisheries Center and has done work in the Great Lakes and Pacific Northwest including Alaska. In addition to work in the Gulf, **Jones** previously facilitated the ecosystem management goals workshop for Atlantic Menhaden on behalf of the ASMFC.

All other participants at the table and in the room introduced themselves.

Agenda Overview

Jones offered thoughts on the agenda and how the workshop would proceed. First, **Schueller** will provide information on the last stock assessment, and then, the group will review the goals and objectives developed at the first workshop and get a brief background on reference points (RPs). **Schueller** and **Chagaris** will provide insight on ecological reference points (ERPs) developed on the Atlantic and the model status for the Gulf.

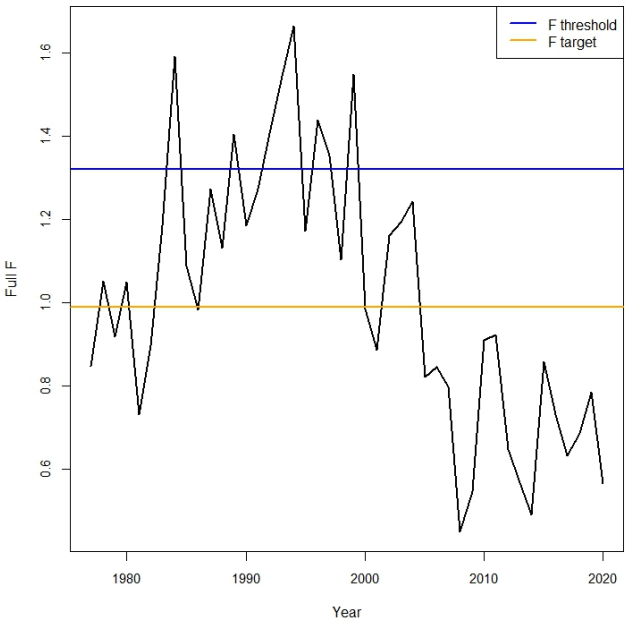
The group will consider options for the region and evaluate the pros and cons before the roundtable narrows down a list of potential RPs in preparation for the upcoming assessment.

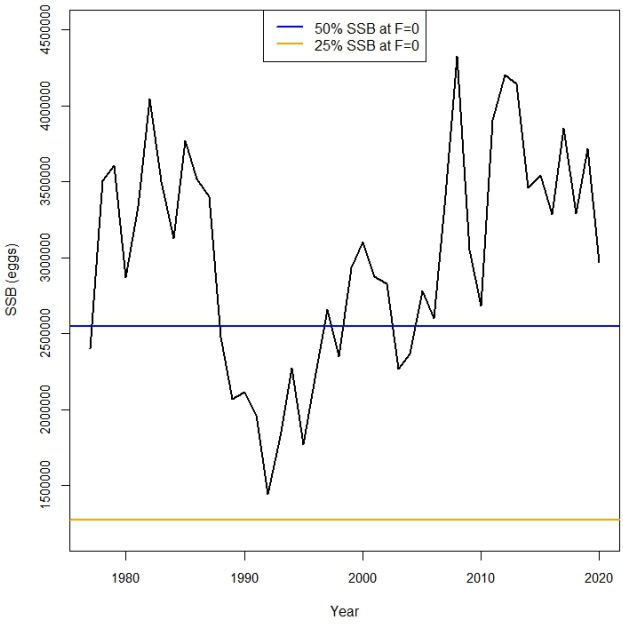
Update on Status and Recent Trends for the Gulf Menhaden fishery

Schueller provided an overview of the most recent update assessment (GDAR03) from 2021. The assessment was conducted using a statistical catch-at-age model (the Beaufort Assessment Model; BAM) and included data from the commercial bait and reduction fleet, the recreational landings (MRIP), and the reduction age compositions. The landings data were included from 1977-2020. Two indices of abundance from the states' fishery independent sampling (FID) were included. One adult index based on the LA gill net survey, and one recruitment index based on the LA, MS, and AL seine surveys. The seine index includes 1996-2020 data, and the gill net index includes data from 1988-2020. Life history information included mortality estimates from the historic tagging data, weight-at-age, fecundity, maturity, and sex ratios.

The benchmarks or RPs used in the update were F=M and F=0.75M for threshold and target, respectively, with $F_{threshold} = 1.32$ and $F_{target} = 0.99$. Spawning stock biomass (SSB) RPs based on fecundity were used for the threshold and target and were the 25% and 50% equilibrium value of SSB (fecundity) for an unfished stock (F=0).

Landings have declined since their height in the 1980s and have averaged around 500,000 mt annually with some variation in the most recent years. The indices were fit fairly well. Fishing mortality has been decreasing since the peak in part due to consolidation of the fleet and reduction in the number of plants and vessels in the Gulf. Current F is around 0.7 since 2010. Based on the F threshold and targets, the fishery is well below the target, and according to the SSB benchmarks, the number of eggs is much higher than the target.





In the update, a number of sensitivity analyses were run, which included the M estimates derived from the two Ecopath with Ecosim (EwE) models (Gulf-wide and Northern Gulf of Mexico; NGOMEX). The general difference between the two sensitivity analyses was in the variation in age-0 or recruitment natural mortality. This was an exploration of including a time varying M value to account for predator-prey dynamics.

For the stock status, again, the RPs of $F_{threshold}$ = 1.32 and F_{target} = 0.99 and $SSB_{threshold}$ = 1.27M and SSB_{target} = 2.55M were used. The population was not overfished, and overfishing was not occurring. Stock status agreed across the sensitivity analyses. These RPs were used because MSY was undefined. SSB (fecundity) was included because fishing effort was unlikely to cause a detrimental decline in the fishery given the population is able to spawn prior to fishing. SSB (fecundity) was a better indicator should the population suffer some reduction in productivity. Both sets of RPs have been used in other fisheries and were accepted by the CIE reviewers in SEDAR65.

Himchak asked that if we aren't completely satisfied with the F and SSB benchmarks, are there others that we're reaching for? **Schueller** reminded that are no easy answers to that, especially since these are forage fish. **Jones** suggested to wait and continue this later as this sets the stage for upcoming discussion.

Butterworth noted a couple recruitment spikes in 2011 and 2018 that the model didn't fit well. **Schueller** pointed out that the model has a hard time making huge jumps (3X to 4X) higher in one year. That's an artifact of the model limitations. **Higgins** said that in the last stock assessment, M was the primary source of uncertainty in the model, and asked if any studies are going on to reduce uncertainty? Also, how is predation mortality being quantified in the model. **Schueller** stated that total M includes all the sources of natural mortality (predation, disease, etc.) but doesn't include the annual variability that is known to happen. M is the most uncertain parameter in all assessments, and good

estimates require data like tagging studies, which is something available for Gulf Menhaden. A Leaf student is looking at the historic data but results are not ready. **Leaf** indicated that the new analysis isn't going to change the estimates of M very much. **Schueller** noted that the F-based RPs were considering natural mortality and where we expect the highest natural mortality on Gulf menhaden is on age-0s through age-2 which is also the largest component of the total population. The fishery primarily harvests age-2 fish.

Butterworth noted that RPs are not fundamental. The basic objective is to work around MSY and using B_{MSY} is preferred but since that is undeterminable, proxies may come close. All are plausible proxies for F_{MSY} so keep the objective in mind, not the RP.

Higgins asked about the portion of mature fish between age-0 and 1 and the timing of spawning. **Schueller** said that age-0s are zero percent mature, age-1s are 80% and age-2s are 100%. Brown-Peterson revised this a few years ago using histology, which significantly adjusted their understanding of the life history. The results indicated that menhaden will spawn multiple times, and over a longer period. **Higgins** asked a follow-up question related to the birthdate of the fish for the assessment. The birthdate of Gulf Menhaden is January 1. Therefore, the model counts ~9-month-old fish as age-1 on January 1 because it's an annual time step.

Butterworth noted when looking at the RPs, do not get on the wrong side of MSY. Even though there is no indication of a stock-recruit relationship, stay in the current range of egg production to avoid putting the resource at risk.

Review of Previous Goals/Objectives

Jones provided the overall goal that was developed by all the stakeholders during the first workshop in February 2019. The group had ended that workshop with the following:

> "Balance the needs of fishery and needs of ecosystem to maintain long-term sustainability such that user groups accept shared responsibility for maintaining and improving ecosystem health, population abundance, and biodiversity and have confidence in the sustainability of the fishery, the industry, and in management."

In addition to the fundamental objective, there are a few 'means' objectives, those things that would be necessary to achieve the fundamental objective. They include 1) maintaining adequate SSB for recruitment, 2) minimizing the negative effects on predators and habitat, 3) minimizing bycatch, 4) maintaining a sustainable commercial fishery, 5) be able to inform management with good assessment data, 6) allow management flexibility, 7) consider environmental factors, 8) maintain historic range and productivity, 9) improve monitoring and assessment, and 10) develop management regimes sufficient to fulfill other objectives. This is a pretty comprehensive list but **Jones** wondered if anything was missing.

Cresson wondered what 'minimizing effects on predators and habitat' meant. It was not clear but was on the list. **Jones** noted that everyone at the first meeting threw out ideas and this likely came up during that exercise. **T. Moncrief** doesn't recall anything specific; yet more toward the predator however, probably a catch all for environmental services. **Mareska** thought discussing habitat loss in Louisiana, for example, was part of the discussion. **Butterworth** pointed out that the use of the word

'minimize' indicates a trade-off is implied. **R. Moncrieffe** mentioned that when discussing minimizing bycatch, currently there is no scale for minimizing. He asked if this is basing it on values from 30 or 40 years ago, or are we intending to reduce on a continuum or at least more recent value basis?

Schueller wasn't clear what 'management regime sufficient to fulfill other objectives" meant. **Himchak** went back through the appendix of the first report. It is hard to understand what individuals meant back in 2019 as several were very broad. **Jones** believes that the last objective means whatever objective you want to achieve will require some management intervention or an action. **Adriance** agreed this was about the management flexibility and authorities that were in place at that time.

Reference Points Overview

Jones provided some background on RPs in general and what items need to be considered for discussion. Definition of a RP from PEW Trust: "Reference points are the benchmarks that scientists and managers use to compare the current status of a fishery to a desirable state."

Generally, RPs are talked about as limits (what to avoid), targets (something to aim for), and triggers (something that causes a management response). All RPs require a definition of a state that is considered acceptable or not acceptable (undesirable). Most of this discussion would be what is a 'desirable state' for Gulf Menhaden. A distinction between *theoretical* vs *empirical* RPs was made in the first workshop. *Theoretical* is model-driven that still requires data. These would be measures such as $B_{MSY,}$ which are derived from an assessment. Those may also include fishing rates (F), and a fecundity/biomass estimate, all of which are informed by the model.

Empirical RPs focus primarily on existing data or indices, such as a period in the past when a population was healthy or not healthy. The indices are able to be tracked over time and can be used to establish a trigger response. An example is the Harvest Control Rule (HCR) as explored during the second workshop in July 2019. The survey index value in the HCR was 0.8, which was relative to population conditions in 2017 and serves as the trigger for the risk that was determined to be acceptable. This was derived through simulations to ensure it would reduce the risk and was appropriate.

Atlantic Coast Reference Points History

Schueller presented the history of the RP development for the Atlantic Menhaden fishery up to the current ecosystem-based RPs (ERPs). The ASMFC began significant management of menhaden in 1981 with some seasonal limits and management triggers in the fishery management plan (FMP). The FMP was revised in 1992. Both FMPs acknowledged the need to consider ecosystem services since menhaden are a forage species. In 2001, Amendment 1 included the term 'ecologically sound' in their objective and added in RPs for the first time using F_{REP} (threshold) and F_{MAX} (target), $SSB_{BMSYproxy}$ (target) and SSB_{MSST} (maximum spawning stock target; threshold). It took 20 years from the first FMP to put in RPs on the stock.

In 2004, another amendment again used population fecundity (FEC) instead of SSB for their RPs since they didn't match well with F. In 2005, the ASMFC instituted a cap on removals from Chesapeake Bay at 109,020mt and in 2011, they moved to SPR-based RPs using $F_{15\%MSP}$ (threshold; MSP – Maximum Spawning Potential) and $F_{30\%MSP}$ (target), $SSB_{30\%MSP}$ (target) and $SSB_{15\%MSP}$ (threshold). In 2012, they amended The FMP again and changed the TAC to 170,800 mt coast-wide for two years and reduced the Chesapeake Bay cap to 87,216 mt.

A new benchmark assessment was completed in 2015. The RPs were adjusted again to $F_{21\%MSP}$ (threshold) and $F_{36\%MSP}$ (target), $FEC_{21\%MSP}$ (threshold) and $FEC_{36\%MSP}$ (target) – historically based SPR RPs. MSY was undefined, so the percentages were made based on max and mean values from an assessment time frame that was deemed sustainable. The TAC was adjusted again to 187,880 mt coast-wide. The expectation was that ecological based RPs would be available with the next assessment. In 2017, the TAC was increased to 200,000 mt. In 2018, the TAC was raised again to 216,000 mt, and the Bay Cap was set at 51,000 mt.

Finally, in 2020, the group landed on ERPs based on an *F* threshold and target and corresponding *FEC* threshold and target. The TAC was reduced to 194,400 mt for 2021-2022.

In summary, the RPs have changed on the Atlantic several times since 1981 due to changes in the goals and objectives for the fishery. The RPs are not MSY-based since there is no stock-recruit relationship, and the yield curve is does not have a peak. Changes in the assessment configuration resulted in changes in the SPR-based percentages. Arriving at ecological based RPs took many years, this is not a quick process. The single species RPs are based on historical values with a time frame of sustainability. The ERPs were compared to the single species RPS and by pairing the two approaches, and the ASMFC successfully moved to using Ecopath with Ecosim (EwE) for coast-wide management.

T. Moncrieff wondered how a species was determined to be ecologically dependent on menhaden. Is there a threshold percentage of diet to determine a key predator? There was a distinct diet connection of Bluefish and Striped Bass to menhaden on the Atlantic, but nothing like that has been identified in the Gulf. **Chagaris** will cover this in his next presentation.

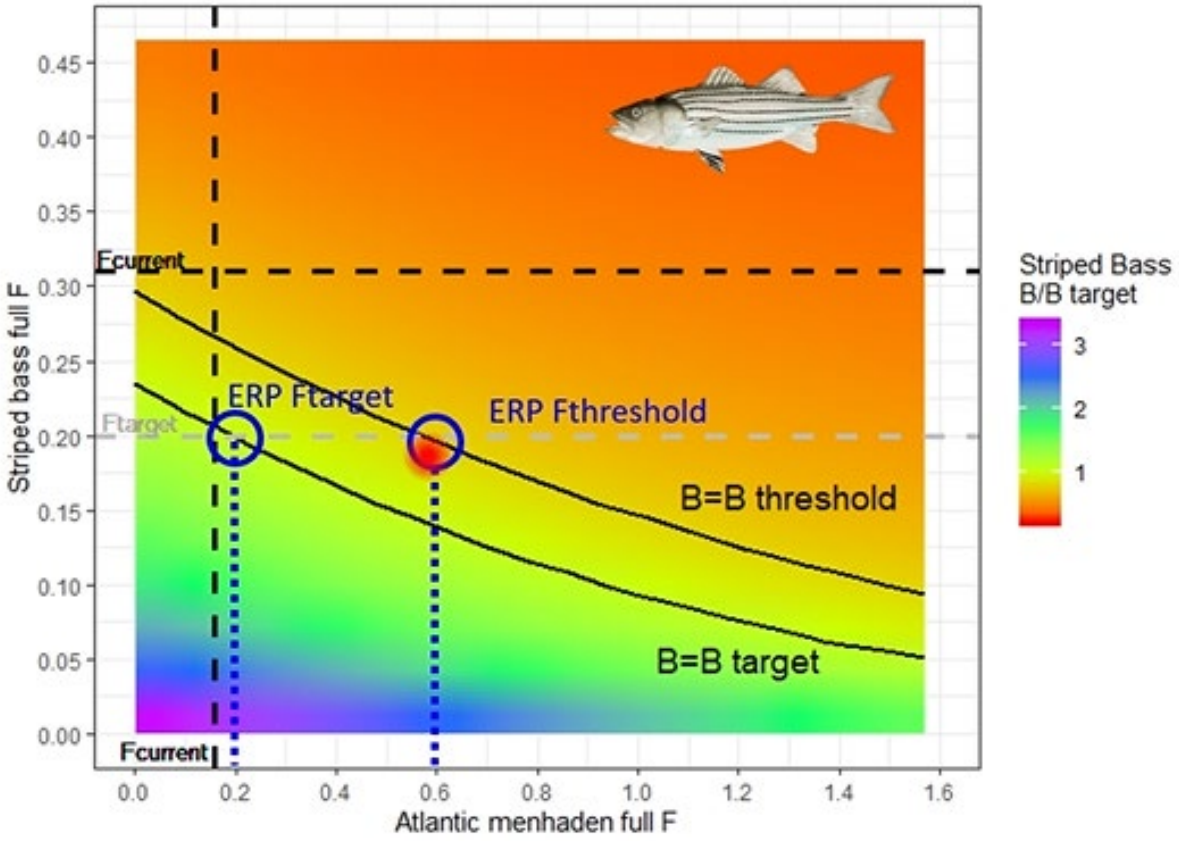
Jones noted that the ERPs didn't result in a big change in the TAC, so does this mean that the single species RPs were pretty closely matched to the ERPs? **Chagaris** noted that the TAC was very precautionary when first established, which resulted in the allowance for a loosening as more assessment work occurred.

Ecosystem-Based RPs Overview on Atlantic

Chagaris reviewed previous presentations made over the last several years to the MAC regarding the development of the two primary EwE models in the Gulf; the Gulf-wide model and the Northern Gulf model (NGOMEX) and the history on the Atlantic. On the Atlantic, a previous ecosystem model of the Northwest Atlantic Continental Shelf (NWACS) was developed by Andre Bucheister, using EwE, and that model was simplified down to 17 groups to focus on the key predators managed by ASMFC. They also removed groups (mammals and birds) with high uncertainty and few data that were not strongly tied to menhaden and retained predators managed by the ASMFC. The revised Model of Intermediate Complexity for Ecosystem Assessment model or NWACS-MICE (MICE from here on) model was easier to update within the assessment and management timeframe, and provided some gains in computational efficiency, which turned out to be helpful when fitting the model and running diagnostics. To develop the ERPs, determining those predators that were critically tied to menhaden was needed, so evaluations of those using the full model were completed since a larger suite of predators was included. This showed Bluefish and Weakfish had a weak response while Striped Bass had a strong response to menhaden harvest, along with shore birds. This meant the MICE model was at least representing the most sensitive species for which the ASMFC has management authority, and

an assumption that any ERPs that sustain Striped Bass should also maintain other predators that are less sensitive. Based on that rationale, forward movement was made with developing ERPs based on the menhaden/Striped Bass tradeoff curve.

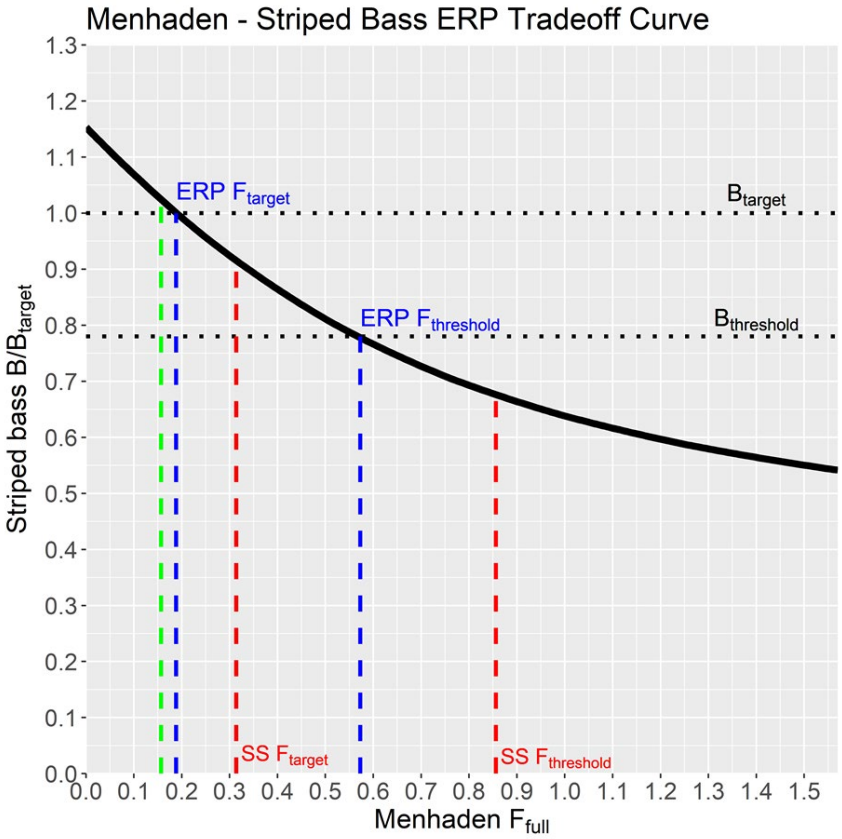
The NWACS-MICE model was calibrated to time series of abundance and catch, and the ERPs were established by running 40-year projection scenarios over a range of menhaden and Striped Bass F combos from high to low fishing mortalities (F). Striped Bass was chosen as the indicator species for the purposes of ERP development because they were most sensitive to menhaden harvest, and therefore, any improvements to Striped Bass would also enhance the biomass of predators that were less dependent on menhaden. The terminal year, equilibrium Striped Bass biomass from the projection scenarios, was taken to develop a surface plot that shows Striped Bass biomass as a function of menhaden and Striped Bass F. The two curves indicate the F combinations where Striped Bass reach their biomass target and threshold. Warmer colors in the top-right region of the plot are where striped bass are below the biomass threshold and cooler colors on the lower-left of the plot are above the biomass target.



Under their current F (black horizontal dotted line), Striped Bass remained below the biomass threshold over all menhaden F rates considered. In order to rebuild the Striped Bass stock, F must be reduced. This was consistent with the most recent Striped Bass stock assessment available at that time, which determined the stock to be overfished and experiencing overfishing. Under current menhaden and Striped Bass F, they would reach equilibrium at about 66% of their target biomass (Striped Bass $B_{current}/B_{target} = 0.66$).

To rebuild Striped Bass populations, a target F rate has been set at 0.2 (horizontal gray line). The MICE model was used to determine what level of menhaden F would not compromise Striped Bass' ability to reach their target biomass under the rebuilding plan. At Striped Bass target F, there is a range of menhaden F rates that maintain Striped Bass biomass between their target and threshold where the lines intersect and are circled.

The graph below shows the effect menhaden harvest has on Striped Bass when Striped Bass are fished at their F_{target}. The ERP F_{target} is defined as the maximum menhaden F that maintains Striped Bass at their biomass target, and the ERP F threshold as the maximum menhaden F that maintains Striped Bass at their biomass threshold. It's worth repeating that in these scenarios, Striped Bass are fished at their F_{target} and all other species in the model were held constant at status quo F rates. The figure shows both single species Atlantic Menhaden reference points in red, and the ERP reference points in blue.



Clearly, the ERPs are more conservative (about 30-40% lower than the single species F-based RPs) but are still slightly higher than current 2017 F rates. The Atlantic Menhaden Management Board approved the reference points (below) and fed them back into the menhaden stock assessment model projections to establish total allowable catch (TAC).

Reference Points	Single Species (SS)	ERP
$F_{current}$	0.16	
F_{target}	0.31	0.19
$F_{threshold}$	0.86	0.57

Himchak noted that on the Atlantic, there was an advantage considering that they already had significant data on the primary predator there. What key predator/prey relationship could be built upon in the Gulf to establish strong links that reach Atlantic points? **Chagaris** responded that a myriad of data had already been vetted over many years from the ERP workgroup, and those were used to identify key predators. **Schueller** reminded that there were several models beyond EwE that contributed to the process as well for the Atlantic. Despite the relationship between menhaden and Striped Bass, there were other predators such as Bluefish and Weakfish that also had their own species-specific thresholds and targets for the management board to consider and lots of discussion of the options.

T. Moncrieff came back to his earlier question. There were monitoring programs for the other species being considered. What was keeping shore birds from being included? **Chagaris** noted that a lack of data (coastwide abundance estimates and diet) was the reason, and they weren't under the purview of the ASMFC to manage. **Landry** wondered what percentage of the diet was the cutoff point for some of these other predators? **Chagaris** recalled that menhaden had to make up somewhere around 20% or so of the species diet. There wasn't a hard number they stuck to, however, that was in relation to other predators without much information. **Schueller** explained previous models such as the multi-species VPA had a suite of species, as well, which were also important in the goals and objectives for the current management and model. **Chagaris** stated that alternative prey sources in the diet analysis was also included. **Higgins** wondered if the alternative prey were at their biomass targets, too? **Chagaris** indicated there were a few that had monitoring and their own targets/thresholds. They could also turn on prey switching in the model, which opened consideration of spatial/seasonal dynamics. **Jones** wondered what the reaction was for the latest management changes. **Chagaris** commented that, based on press releases, there appeared to be support from the eNGOs and other groups for the move to ERPs.

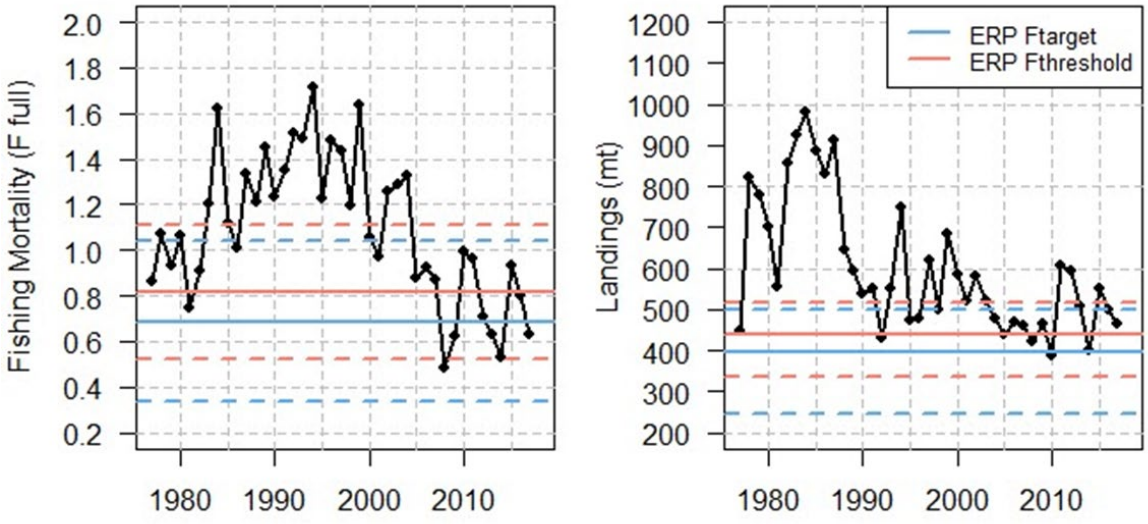
Ecosystem-Based RPs Potential in the Gulf

The Berenshtein et al. (2021) technical report identified the data inputs potentially available for ecosystem model development. The Berenshtein et al. (2023) paper walked through a framework for developing ERPs for Gulf Menhaden while highlighting uncertainties and needs for future work using both the Gulf-wide EwE model and the northern Gulf model (NGOMEX). **Chagaris** wanted the group to focus on the framework more than the specific values of the RPs presented. The collaborators on the paper have presented a number of times to the MAC as they worked on various aspects of the model, and Berenshtein provided, at the October 2021 MAC meeting, most of the results that are ultimately synthesized in the 2023 final paper.

The Gulf Menhaden model was funded by the NOAA Restore Act starting in 2017. The goal was to integrate information on eco stressors and predator/prey interactions for use in future Gulf of Mexico stock assessments. EwE was used to look at the static ecosystem and the time series of various parameters to forward project. The model is based on 1980-2016 in the Gulf-wide EwE model. In the paper, everything is compared to that time period and includes 78 functional groups ranging from marine mammals to detritus and phytoplankton. There is a highly connected foodweb in the Gulf where predator species are eating everything, making the larger model quite complicated.

The RP development framework was adapted from the process for Atlantic Menhaden. First, targets and thresholds for the predators were identified, then tradeoffs looking at equilibrium projections under various combinations of menhaden and predator F were developed, and finally, ERPs targets and thresholds at the fishing mortalities were identified. This is similar to what was done in the Atlantic except there is no single predator like Striped Bass. For the Gulf, the group looked at the top ten most sensitive predators rather than one single 'most important' predator and included several shark groups, drum, mackerels, and other coastal and pelagic predators. Each predator has its own ERP target and threshold, which was averaged into a single ERP. These were sensitive to both removal of prey as well as impacts from bycatch, (different from the Atlantic, which did not include bycatch). Once ready, the ERPs were tested in the BAM model.

Again, this is similar to what was done in the Atlantic except that there isn't one single predator like Striped Bass. The projection period used the ERP, and the results include the blue and red horizontal lines to look at the fishing mortality and landings in relation to the ERP (below). The mean ERP F_{target} and $F_{threshold}$ (expressed as a ratio to the 2016 F in Ecosim) were converted to a fully selected F (F_{full}) for comparison with historical F estimates from the BAM by multiplying the ratio by the 2016 F_{full} from the stock assessment. This equates to mean ERP F_{target} and $F_{threshold}$ values in F_{full} units of 0.69 and 0.82, respectively.



In the figures above, the horizontal solid lines equal the mean ERP F_{target} and $F_{threshold}$ averaged over all ten predator species, the horizontal dashed lines represent ±1 standard deviations. Observed landings since 2003 are generally within the range of the ERPs. Between the solid lines is where the fleet could

operate based on F, and theoretically, the upper and lower dashed lines could be used to determine targets (on the lower end) and hard thresholds for a TAC.

After the publication, there have been a number of questions about the results. The takeaways are that menhaden removals can have substantial effects on other species due to predator-prey interactions, bycatch, or a combination of both. The framework achieves B_{target} for predators by modifying fishing on menhaden and/or the predator, and based on these relationships, menhaden ERPs were established. Based on the current example ERPs, a small reduction in menhaden fishing pressure (-14%) from 2016 levels is needed to reach the ERP F_{target} equivalent to the F_{full} of 0.69. However, there are a number of model limitations such as the need for more diet data. Resolution to species level and size/age of prey item where possible are also needed. This could be done with comprehensive stomach sampling similar to the work being conducted by Dr. Justine Whitaker at Nicholls State. We also need updated bycatch by weight from the fleet such as the one GSMFC has entered into with LGL. The new data gathered in both these studies should be incorporated into the model to revise the ERPs.

There are also modeling needs associated with the Berenshtein example. A thorough sensitivity and uncertainty analysis around the ERPs exploring alternative diet matrices, vulnerability parameters, and bycatch ratios should be conducted, and filling gaps through diet composition (Ecopath), depth distribution (Ecospace), habitat preferences (Ecospace), and maybe seasonal migrations (Ecospace) should be considered. Spatial components are needed to better capture predator-prey overlap, fishing effort, and environmental conditions. Developing other models to explore like those done on the Atlantic with the MICE model is needed, and any models must be reviewed and vetted. All of this should be done with input from the MAC, and only if managers are serious about adopting the ERP framework for management.

Leaf referred to the diagnostics of the direct impacts from the bycatch versus the impacts from the removal of the prey. Both could be managed separately by the fleet spatially without affecting effort. The removal of prey couldn't be managed without affecting effort. Is it useful to disentangle the prey versus bycatch impacts to potentially develop separate RPs for each for management? **Chagaris** thinks this might be something to consider. **Leaf,** like others, is a little concerned about the assumed trophic linkages. Everyone is interested in the strength of the foodweb ERPs.

T. Moncrieff wants to better understand how the key groups were selected considering that 'sea trout' were very low on the table. **Chagaris** knew that there were concerns over Spotted Seatrout since they consumed menhaden at specific sizes in specific locations. **Adriance** noted that the 'sea trout' data from SEAMAP is likely not all Spotted Seatrout and may not be the best data source for that species. **Butterworth** spoke as a collaborator for a review of how ERPs have progressed and how they are being used in management world-wide. The Atlantic Menhaden fishery is the only fishery using ERPs in management. This significantly shows the difficulty of applying ERPs. He did suggest that there really isn't a RP for the predators because of multiple sizes and life history stages on a single predator with different consumption rates that would have to be averaged. Using a single prey and predator is much more complicated than realized.

Louisiana Purse Seine Bycatch Study

VanderKooy announced a new bycatch study underway in Louisiana. The State of Louisiana asked GSMFC to seek proposals and administer the project. A couple of proposals were submitted, and outside experts provided reviews from similar industrial fisheries from Peru, Norway, and Australia. LGL Ecological Research Associates, Inc. was awarded nearly $1M to conduct research next season from the April opening through October/November 2024. There is currently a pilot study underway to work out the methodology prior to next year. The intent is to use 'run boats' since they have a crew of four as opposed to a regular steamer, which will allow more space and time to work up samples in detail. Cataloging the catch as well as conducting a fate study to determine the mortality of released bycatch 24-48 hours after the net set will happen. **VanderKooy** reported that one of the PIs on the project will present to MAC in October 2023. There is only funding for one year with work ending June 2025.

Reference Point Options for Gulf Menhaden

Jones began a discussion about the 'why' of RPs. The workshop's job is not to produce RPs for management but rather advise agencies responsible for management as to what should be considered and might be appropriate as RPs. When these workshops first started, the industry was working towards MSC certification and RPs were important needs for industry. In the case of Atlantic Menhaden RPs, those were used to define a TAC and determine what the ASMFC considered an appropriate harvest level. That may not be the case in the Gulf.

Butterworth noted that the MSC requirements haven't gone away and are going in the other direction with more demand for HCRs because RPs are meaningless until a management action is put into place. **Himchak** reminded that MSC certification began in 2017 with no HCR. It was suggested at that time that using the independent data to develop indices to track the fishery was a great approach. The industry worked with Leaf to develop a portal to load and view the data and operationalize the process. Essentially, the industry has what it needs to self-manage if the state agencies don't see a need to adopt the HCR. **Landry** doesn't want it interpreted that this is an industry driven process. Establishing RPs should result in the industry, eNGOs, states, and feds having a level of confidence that the fishery is sustainable.

Other comments from **Higgins** included concern that specific metrics for prey are needed and are not in the fishery management plan as of right now. While an abundance index is great, this doesn't explicitly measure how harvest is affecting the major predators that rely on menhaden to maintain their biomass targets. **T. Moncrieff** indicated that the largest biomass fishery in the Gulf, which has profound ecological and economical impacts throughout the region and environment, has been operating sustainably in the last decade and matches with the ERPs from the EwE model. When trying to update RPs based on new fecundity data, redefining appropriate RPs is needed to show progress has been made on the ecosystem-based models. Current harvest levels appear to be sustainable yet do not alleviate the need to establish RPs for making comparisons across assessments over time and continual re-evaluations where the population is going. Due diligence is required to see if these new pieces of information can be applied into the current management scheme. **Adriance** added that bringing in ecosystem components ultimately means scientifically-based reference points need to be stated. While there may be differences on the readiness of the ERPs, by exploring them, scientifically sound single species RPs can be generated.

Higgins wanted to know how the modelers see this process moving forward in the Gulf compared to what happened in the Atlantic? **Chagaris** stated that we've come a long way in a short amount of time, which was benefited by the Atlantic process. Still, the management framework lacks, and the Gulf Commission doesn't have the authority, so no clear path is there to drive ERPs for management. Ultimately, the state agencies unlike the ASMFC are the audience for these discussions and will make the management decisions. **Schueller** said Atlantic has a very specific framework with every species having its own technical committees, assessment teams, and management teams. Gulf Menhaden management is set up very differently.

It was agreed that, procedurally, the MAC is the overarching body working on the assessment and should evaluate RPs before recommending to the full Commission, and upon completion of the assessment, the agencies may look at the suite of options and determine where management will fall and if the RPs would be actionable at the state level.

Butterworth reminded that RPs are the end of a process, they're the output, and satisfactory models are a must to get to RPs. While the Atlantic sets a good example, that may not be a route for the Gulf. First, the diet data just doesn't exist for the Gulf. Second, the EwE is much too complicated model because over half of the fits of the model to the catch are just bad and would be thrown out if it was a single species assessment. The eco-models used elsewhere are using only a few of the components that are critical for management to simplify their models. The Gulf model would benefit from being reduced in complexity. Focus on the predators that are known to be critical and take out the less informed groups, similar to the MICE model for the Atlantic; create a minimum realistic model for a reasonable chance of getting a useful output.

Cresson addressed from his perspective why the group was present especially with several fisheries experiencing challenges in Louisiana right now. There may or may not be a relationship between those issues and the menhaden fishery, which is something needed to be known. How can we use these tools down the road to better manage those other fisheries in the future? What is the relationship and how can we manage for all the other species. **R. Moncrieffe** urged to not wait 20 or 25 years for a perfect model and wait for the best available data. The Atlantic model did a good job of re-evaluating the catch limits and could do it year-by-year, so copying that part of the model would be important to use with the data on-hand here and now.

Single Species RPs

Jones laid out a proposal for moving forward by having everyone think collectively on what the RPs would be for a single species. What are the set of RPs sufficient for management for this single species? Are the RPs that Schueller presented this morning sufficient for single species management? **Leaf** noted that we already have a good handle on empirical and model-based RPs, which have been already explored in two assessments. He believes there isn't much else out there that hasn't been considered. The integrated gillnet and seine index as well as the assessment model-based RPs associated with fishing mortality (F) and fecundity/biomass exist, so what else is there? Others have been looked at and didn't pan out since they were based on MSY.

Chagaris wasn't clear if the RPs from the BAM model have been blessed at this point. Maybe there are alternatives in the RPs that could still be considered in the model. In most assessments, there is ample discussion about the RPs and how they can be applied to management. In the case of Gulf Menhaden,

the assessment is more about determining stock status and less about creating actionable responses to the RPs by management. **Schueller** agreed, the history in the assessments have moved to various RPs over time but never settled on something. **Jones** said that the group doesn't appear to be unhappy with the previous RPs and asked if there is actually a right and wrong for the RPs? **Schueller** thought that a little more discussion could help us better define RPs rather than seeing what works at the end of the assessment. **T. Moncrieff** stated knowing what's 'right' will not happen until the RP runs for a little while. He has been more in favor of using the historical landings levels for potential management guidance. He also wondered if there are any problems with using those RPs.

Butterworth explained again that having a RP isn't the end all for the work and doesn't help if there is no way to be implemented. The RP needs to be evaluated. Deciding on a RP comes from using simulation tests to determine which option for application is expected to result in the most desirable state for the fishery/performance statistics chosen to evaluate performance. Applying the RP to see how it goes without simulation testing is risky. If it's not a good result, it has already impacted the fishery years later.

Referring to the previous workshop (July 2019), **Butterworth** elaborated on how simulation testing is conducted. He explained that a practical Management Procedure (MP) approach moves beyond the typical stock assessment because it takes the uncertainties into account. However, it does not replace the assessment; rather, the assessment provides the basis for the tests of the MPs. A harvest control rule (HCR) is developed to regulate harvest in response to assessment information, the goal being to avoid potential problems in a population. Using the HCR, one can run simulations under a wide variety of conditions, allowing managers the ability to explore the most extreme cases. The overall goal of the MP is to develop a HCR based on RPs that is robust to inaccuracies in the assessment.

Leaf understood that this appears very 'ad-hoc'. At two different meetings, discussions have centered around a desire for ERPs, which cannot be accomplished yet and they almost need to reverse engineer the RPs to make them fit. The RPs aren't perfect but even the reviewers of the assessments understood that well-determined and thoughtful attempts were made despite the limitations, even without a rigorous management evaluation. A long list of RPs that had been used in other regions/locations was presented in the first workshop and the group discussed how each worked and why these weren't relevant for our particular species.

Jones pulled the group back to the need to re-evaluate the candidate list we identified before and asked if any others need consideration that perhaps weren't already identified. We have the status quo RPs, which Schueller presented during the morning session, and variations on those RPs as suggested by Chagaris (i.e. excluding age-0 from the reference M calculation). At the first workshop, nobody thought much more could be informed by the assessment models. Moncrieff had also suggested the RPs that are using the independent indices to evaluate a point in time where the stock was perhaps lower due to fishing effort. The idea being that we don't want to go back to that level. While it's not clear if it was bad, it was certainly different and there were fewer fish. Butterworth choose 80% of the 2017 level as the RP in the HCR evaluation (Workshop #2), which is similar to the 'history-based' RPs.

Landry wondered if there were RPs we wouldn't want to explore because they would be too risky and therefore should automatically be eliminated? **Schueller** said that those were probably off the table, especially the ones around MSY. Selecting something based on history could be risky if we choose

something too high. Federal mandates exist for most federal fisheries to work around MSY but that's not the case for the two Commissions. Whatever this group lands on has to be scientifically supportable. **Jones** thought RPs such as MSY just aren't meaningful and picking F based RPs that would not maintain the sustainability of the stock could be the group's choice. **Himchak** reminded that all RPs are about the stock, not the fishery. **Butterworth**, proposed that assuming F=M is the choice, you don't want to go to a place where you don't know if a problem would happen. Running a simulation, it may be found to be very harmful. However, F=0.75M would appear to be safer considering Schueller's assessment. **Himchak** wondered the possibility of exploring the fecundity levels in the past where biomass was truncated. **Schueller** reminded this is a short-lived species able to spawn prior to fishing effort, so that might not be a measurable relationship.

Ecosystem-Based RPs (ERPs)

Chagaris' morning presentation indicated that the ERPs in the Berenshtein et al. (2023) paper were an aggregation of ten groups of species that are impacted by menhaden fishing either by removing prey or as bycatch in the directed fishery. Based on that, a B_{target} for menhaden was generated for the benefit of the ten species groups. The Biomass target was 75% of F_{MSY}. What other approaches could we put on the table? Instead of an average of all predators, maybe take the single, most critical predator's RP. There were other tradeoffs in the paper as well which could be considered indicators; the biomass of all predators combined; the ratio of menhaden consumed to menhaden landed; the total menhaden consumed as a function of fishing mortality; and the trophic level of the catch. The challenge is that you aren't able to develop targets and thresholds when those components are combined. How do we value a menhaden in the purse seine vs in the predator's stomach? If they're equal, then one could argue having the same of each as a possibility. **Higgins** wondered what the pivot point for management is now? Are number of eggs, historical landings, levels of F… will the state agencies make that decision for their respective waters? In ERPs, what would be good in combination for the most vulnerable predator in each state? **T. Moncrieff** didn't have any species that are high concern. The work done over the last several years for a single species RP has been good, however, is there a way to have that in a blended form, or is it one or the other? **Jones** wondered what would be a reasonable level of comfort for addressing predation, generally speaking. The ERPs weren't really that far off from the BAM model RPs. While not equal, this establishes a reasonable state of the population.

Butterworth made three points. In the forage fish (LENFEST) approach, instead of reducing population by 50%, you only reduce it by 25%. From an ecological theory point of view, if you want to harvest appropriately, you need to harvest all species by the same amount, predators, prey, and others, remove all equally. The one **Butterworth** liked is a multicriteria and optimization approach where you DO evaluate the value of the prey item as predator food versus commercial harvest. All three approaches are in-use yet none are ideal at the moment. Is there a way to think about ERPs that tries to capture the value of menhaden to the fishery and the predators? It's a matter of opinion on how to value that.

De Mutsert noted testing any of these RPs or ERPs hasn't really happened. Single species are below targets and thresholds while ERPs are closer to targets and thresholds (perhaps by chance). There must be a way to test these effects. **Jones** agreed and also noted that some risks in the single species already mentioned such as F=M are possible because we haven't tested. **Jones** wasn't aware of any other cases where biological RPs were derived from an EwE model but has seen them from single species models. What might be a sentinel species that we have management and assessment for as ERPs and could be

compared to the EwE model outputs? **Chagaris** compared their results to species with regional stock assessments. If a MICE model is used in the northern Gulf, we'd want to include Spotted Seatrout and Red Drum, at a minimum, as well as alternative prey. A future MICE model should be codeveloped with input from the MAC.

Himchak wondered if the natural mortality (M) by age is just better in menhaden. If the abundance is naturally high in the water or fishing is at a precautionary level, could the ERP value be equal to the age of cutoff? At some point, there might already be enough fish in the water. It's possible that the EwE model is already accounting for that M2 is equal to M1. M2 is the part of mortality that is consumed by predators, and M1 is the mortality from disease and other natural causes. **Butterworth** noted that M in multispecies modeling, in general, such as VPA or age-structured models, the M2 is considered in the model. However, secondary interactions caused much more uncertainty and caused those approaches to no longer be used.

R. Moncrieffe wondered why seabird data was excluded from the NWACS -MICE EwE. If those data were available for diet and bycatch, would there be interest in including them in the EwE model? **Chagaris** will be addressing this in another couple weeks with the ASMFC, but the inclusion was determined by the committee on the Atlantic. There still isn't much data associated with this predator group, so it still may not meet the minimum for inclusion yet will be discussed. **Higgins** wondered about the age-specific M asking if we're overdue for an M specific study by age for this? She thought the fishery should be considered a predator that is age selective. What does that mean for the ecosystem? **Jones** believes that in terms of the fishery, the M by age is explicitly included in the model. With respect to the predators in the EwE, you would need to know the M2 component specifically. The tools could deal with it, but the data to inform on an individual predator's selectivity curve isn't available. **Chagaris** noted the age structure is included in the Atlantic MICE model, which addresses if the predators took a high number of age-0 and age-1s before prey recruit to the fishery. **Leaf** has reviewed most of the diet data in the Gulf, and the size of the prey isn't really included, so talking about size or age selectivity from those studies is null. The annual variability of growth IS understood in the Gulf. It is highly variable and driven more by environmental parameters. **Schueller** has time-varying growth on the Atlantic, but that pattern isn't present in the Gulf. A constant growth is in the current version of the Gulf assessment.

Jones wondered if reducing the Gulf EwE to something akin to the MICE model would be possible in the Gulf? **Chagaris** agreed and said a committee would need to determine what predators were the most important in the region. The candidate species would be the mackerels, the sharks, and some bycatch, which are also feeding at the time of harvest. Some of the Sciaenids such as Red Drum and Spotted Seatrout would be considered even though they have spatial and temporal periods of feeding on menhaden. **Landry** wanted to know what else do we need for diet studies? **Chagaris** believed that the work being conducted by Dr. Justine Whitaker (Nicholls State) is the core of predators (west Florida shelf). Not all the prey is Gulf Menhaden but includes other species such as Yellowfin Menhaden. Diet studies are expensive and time consuming, yet ultimately, this is what is needed. Extensive diet matrices that are seasonal and regional in nature could map uncertainties like feeding events not captured in the model. There is a need to look at the suite of predators to determine what gets included, and test the different diet assumptions like what was done on the Atlantic.

Gelpi noted that TPWD has a diet study from the last couple years from the Sabine area, which is available if the modelers had not seen them. **De Mutsert** indicated that in the NGOMEX model, there is diet data derived from SEAMAP data going into the model, not from data reported in the literature.

Leaf suggested if we're considering all options as potential candidates, fish carbon may be an option for potential RP consideration to measure ecosystem production like the northeast (Georges Banks) is using. The model measures primary production to elicit information on the potential for total fish production each year. **Chagaris** stated that EwE models the whole foodweb and includes some phytoplankton, detritus, etc. Some options are available in the literature that correlate Chlorophyll-A production and fish biomass. **De Mutsert** would consider environmental drivers such as biomass reaction to stressors like hypoxia or red tide. **Chagaris** would include those in Ecosim so that the model does not attempt to account for environmentally driven processes using trophic interaction parameters, which improves the quality of the model outputs.

The Workshop recessed for the day at 4:30pm.

Day 2

Evaluation of Candidate RPs

Singles Species RPs

Jones reviewed the list of potential RP candidates from day one to flesh out the pros and cons of each while keeping in mind the objectives.

For the single species RPs, we essentially came up with two F-based, two biomass-based, and one derived from historic index values similar to the one in the HCR.

F=M as limit/threshold
F= 0.75 M as target
B= 0.25* B_0 as limit
B= 0.50 * B_0 as target
RP derived from historical index values (e.g. 0.8*$Index_{2017}$)

For the ecosystem RPs, there were seven options suggested:

Average F_{target} over 10 predator groups (from Berenshtein et al. 2023)
    predator target = 0.75 * B_{MSY}
Target based on aggregate biomass of all predators
Target based on balancing removals by predators and by fishery
MICE model for GoM;
    include sharks, mackerel, red drum, spotted sea trout
LENFEST approach - shift single species target from B_0 50% to B_0 75% to allow for predators
Set removal rates for predators and prey equal
Valuation approach - target based on value as prey versus value as harvest
Identify a vulnerable single target predator species

Working down the list, it was suggested that in our discussions, targets might be better considered as triggers over limits since they should result in a management action.

F=M as limit/threshold

- May not be precautionary without testing, it's just presumed to be a 'safe space'
- F=M suggests a fishing rate as high as a historic high which could still be risky

F=0.75M Target (trigger?)

- Might be a less risky value as a a target, instead of a threshold

Leaf noted that this RP seems ad hoc. Technically, it has been tested historically considering the trends in the fishery over time and given nothing bad happened back then – but has not been tested through simulations. **Chagaris** was concerned with this RP due to how M is being defined. The definition of M may be different if age-0s are not included, which might shift down a little. What is the appropriate metric of M when being compared to F? **Butterworth** stated that F may also be somewhat arbitrary considering the selectivity and age group inclusions in the calculations. **Jones** felt that there may be a way to move forward with F=M, and it may be a reasonable RP, however there may be a need to look at how both F and M are derived. A transparent explanation of how F and M are derived is needed.

The other two RPs we discussed were related to fecundity as a metric of spawning stock biomass.

0.25* SSB_0 as limit
0.50 * SSB_0 as target

Jones noted that in recent years, the spawning stock biomass (SSB) has been high and well above the target of 50%. Are we being too conservative for the lower threshold? **Schueller** indicated that 25% and 50% have seemed reasonable based on the recent assessments, but they don't really match the fishing mortality rate F and are not linked. Essentially, this is an independent check because the RPs are not related. If mismatched RPs are used, the simulation testing becomes more complicated. **Butterworth** agreed with Schueller. These values are more like the levels for a longer-lived groundfish (limits would be lower yet). Generally, you aim higher for forage fish than demersals; for SSB_{limit}, 0.3 or 0.4 is more common. Fishing selectivity won't let you get lower than 0.25, so it's silly and a little arbitrary. **Chagaris** suggested that rather than fecundity-based RPs, perhaps it should be more of a consumption target. Could SSB be converted/reported as actual biomass? **Schueller** stated that biomass for menhaden is difficult to determine due to amount of age-0s in a population, in general, the Gulf menhaden assessments only report age-1+ biomass. **De Mutsert** noted that biomass would simplify the ecosystem-based models as well for simulations. The EwE models follow the age breaks already, so we can determine biomass at each age stage. **Mroch** was concerned about keeping the RPs close to the outputs from the assessment. **Schueller** noted that we use older fish in fecundity because older fish are more valuable than younger fish since they have higher fecundity. **Leaf** noted that menhaden eggs are a high value food item as well for many species by providing valuable fatty acids critical to growth. **Butterworth** suggested that we settle on one metric. If you want to provide additional metrics, they should be extra, not in place of.

The last RP that was discussed for single species is related to the indices. The value used in the example HCR sets a value that triggers a management response.

Historical FID indices ($0.8*index_{2017}$)

Chagaris noted that it would useful to demonstrate that the index was actually proportional to abundance. The indices are based on surveys that weren't designed to monitor menhaden, so are they truly representative? **Jones** remembered that these were part of the assessment. **Schueller** said they were included because the seines are complimentary to trawl data – representing recruitment and the Louisiana gillnets were used for adults. **Adriance** saw this more of a harvest control tool not as a RP. **Jones** thought it might not be that difficult an exercise to look at the correspondence between the threshold and the F=0.75M and cross reference the two. Absent the connection to a biological metric for the fishery, this index-based RP might seem a bit sketchy. **Leaf** noted that more gill net data for MS and AL is available, but that isn't included because they don't correlate well to the LA gill net. **Butterworth** reiterated getting back to basics, and how we cannot do the latter without some level of testing. **Jones** summarized the need to know where this RP would fall in comparison to the biomass RPs discussed earlier. Assumptions may be made that historical high Fs were undesirable AND that less IS desirable. When the index is around 0.8, the biomass might fall in between the SSB limit/threshold anyway. There is no evidence in the historical data that Gulf Menhaden was overfished when the index was lower than 0.8. **Leaf** noted that the lower population of prey may not have been critical if the predators were also low during that time (many declining species in 1980s), which causes more blurring on quantities of prey actually needed for predators. **Chagaris** took the point from Butterworth that there are many fisheries with poor indices of abundance and predators especially, yet this shouldn't be abandoned. We should continue to move forward with simulations like those done in the second workshop projecting changes into the future. Finally, **Butterworth** stressed that simulation testing would be useful/critical regardless of which RP is considered. Common sense must be used as simulations are testing the risk element. **R. Moncrieffe** asked Butterworth which of those options did he prefer. **Butterworth** liked the index-based because it was simulation tested; the others were not. However, with testing, the others might actually be better. Management measures should be based on performance and need some response/control to be associated.

Ecosystem RPs

Jones began running through the candidate EPRs.

Berenshtein Ave F_{target}; Target = $0.75*B_{MSY}$

The primary benefit of this approach is the genuine attempt to identify consumers of menhaden or those affected by fishery bycatch. **Butterworth** noted that the number is in the ballpark where we are now, but it's only a start and needs more work. There are some mismatches in that the absence of diet data and predator abundance levels result in poor fits in some places. Simplifying might make it better and easier to use such as creating a MICE model for the Gulf. **Leaf** has some concern that even with more diet data, the idea that menhaden is the most important prey out there doesn't ring true when considering the very healthy Spotted Seatrout populations that don't overlap the range of Gulf Menhaden. **Himchak** reminded that SCEMFIS is coming up with another five-year grant to fund additional work that addresses scientific uncertainty in our data. This is funded by industry through the universities and is open to projects that would support the latter. **Mareska** stated this ERP is not 'ready

for primetime'. Even with the ongoing diet studies, there's still not enough diet data, and they aren't long-term. The diet data must be spatial, temporal, and seasonal. The diets of Spotted Seatrout in Mobile Bay near heavy submerged aquatic vegetation will be dominated by shrimp. Open water samples combined with availability of small/young menhaden, seatrout will have menhaden in their diets. One-month or one-year of data from one location isn't enough, however. Crevalle Jack is a big consumer of menhaden along with Bluefish, yet there isn't any abundance/assessment data for either of these species. This should be included in the EwE at some point. **De Mutsert** thought that movement to ERPs in the Gulf may be pushed if a specific predator is identified either as primary predator or as significant bycatch. Ecosystem models on the Atlantic were driven by striped bass declines. **Leaf** wondered if we look at the trajectories of species we do have abundances for, does predator condition or weight-at-age increase with increasing menhaden? **De Mutsert** noted that if a simpler MICE model is used, then you could actually improve the spatial components. **Jones** summarized that this attractive approach isn't ready yet. **Chagaris** thought this may, at least, be a moderate buffer from single-species on behalf of predators. **Leaf** reminded that the assessment already includes some predation within the natural mortality estimates. The single-species does have a little ecosystem work in it through that natural mortality component but the buffering part might be questionable. That would have to assume that something related to M is missing otherwise and that's probably not the case. **Chagaris** explained that ERPs work as buffers, considering the bottom-up effect on predators, which is where the buffer would come in. **Butterworth** felt that if going only the single-species route, the buffer that Chagaris mentioned will be missed. One of the key points is related to how the fishery is operating now. It's already below the targets, so would the difference in the two versions be significant; probably not. More needs to be done with the ERPs before they're ready, however, that is not too far. *More importantly, be careful where money is invested in data collection. Run the modeling and collection together to avoid gathering data on something that is unimportant and wastes limited funds/resources.* **Mareska** mentioned that M is included in the assessment. **Mroch** was a skeptic of the multi-species models in the past and was wrong, so he wants to see work continued on the EwE model.

Jones moved to the next ERP approaches.

Target based on aggregate biomass of all predators

Rather than identifying F_{target} for each of the predator groups, put them together and average to get a single indicator. **Chagaris** asked if a more encompassing indicator is wanted. **Jones** wondered if there was a way to take the biomass for all of the groups and do a calculation to define a B_{MSY} for those groups? **Chagaris** thought summing them and developing a yield curve of some sort is possible. **Jones** thinks it could be an alternative over a single critical species as De Mutsert suggested. Pooling them all into a single collective target and exploitation rate might not work but could be a test of sorts for robustness.

Target balancing predator and fishery removals

Jones summarized that this approach would balance the removals from the fishery to the removals by the predators. What is the 'right' place to be so everyone is equal? **Butterworth** suggested that before going down that route to pick a number, a broad survey of what the situation is in other similar fisheries around the world would need to be completed. Equality may not be appropriate, yet few

places in the world probably operate that way. What is the allocation in other places with similar sustainable fisheries? **Jones** said the notion is to look at other ecosystems where there is a commercial fishery for a prey species and evaluate what that proportion is (easy enough to calculate from the model). Probably not very practical but worth discussing. If this is working elsewhere, maybe this could work in the Gulf.

Moving on, **Jones** touched on the MICE model.

MICE model for GOM with fewer groups

Based on the discussion from day one, the key predators to potentially consider would be Sharks, Mackerel, Red Drum, and Spotted Seatrout. **T. Moncrieff** recognized that assessments for some of these species may exist, and sharks have limited assessment. Management is causing under-exploitation in some cases, for example mackerels and Red Drum are underexploited by regulations. Spotted Seatrout predate small menhaden seasonally and spatially. Finding a balance for THESE predators is difficult – landings aren't based on abundance/ecosystem. These are not striped bass. **Jones** wondered if these are the wrong predators to use in the model or if there is just a lot of uncertainty around their data. **T. Moncrieff** thought these ARE the right ones to include because nothing fishery related is impacting their abundances. **Adriance** believed this is useful in the spatial sense if refined, but Blacktips are managed heavily which influences their importance. Their RP is less reliable based on removals. **Jones** didn't think exploitation may not be that critical to the computation of the consumption of menhaden. **Higgins** thought maybe focusing only on Louisiana is important since this is where the majority of the fishery occurs. Louisiana also has some other predator issues as well so spatially, that would be appropriate. Whether they are over or under exploited may or may not be relevant.

Himchak pointed out that if you identify a 'key predator' for the model that is in fact overfished, no amount of prey will bring that species back without reducing or eliminating the fishing mortality on that predator. The industry was concerned that Striped Bass weren't being underfed and were overfished as part of the Atlantic situation. **Higgins** agreed and believed there are a couple of levers to pull related to nutrient loads, hypoxia, etc. but if these aren't considered in a single species assessment, missing these elements won't help either. **Jones** said that knowing how robust any model is enables recognition of changes that might occur in the future related to bottom-up processes. **T. Moncrieff** indicated that if there is a list, ensuring talk about Spotted Seatrout in the model, not the genus of seatrout in general, is needed. **Adriance** wondered if they can include prey switching in the EwE Gulf model. **Chagaris** confirmed that it is included. Currently, the MICE model only includes menhaden as prey. Adding to the predator suite to include thread herring, anchovies, crabs, etc. will be necessary. **Butterworth** strongly recommended being clear on why you want to consider and include ecosystem related parameters when managing menhaden. He said to base it on your objectives and how it would achieve the goals set. **Schueller** was unsure what the list of species should be and given the goals and objectives, she was unsure of what might be missing. If it's not on the list now, it probably won't end up having directed research to address the data needed in the future. **R. Moncrieffe** felt that Brown Pelicans absolutely need to be on the list. **T. Moncrieff** said besides the ones we've already suggested there are other prey species to add to the list, which would also include white and brown shrimp. The fishery-independent data from the states would be easy to look at the abundances the last two decades to see what's available for prey. **Mareska** wondered how the prey

switching works if it's triggered by the biomass of the predators or the biomass of the prey. **Chagaris** says there's two ways: either model a few prey species explicitly or combine them into a catch-all prey group. However, this is speculative since no diet data are available to make these decisions. Something to justify prey inclusion would be needed. What was done on the Atlantic is very different than what we can do in the Gulf at this time.

Jones moved to the last four ERPs on the candidate list beginning with the simplest.

Shift single-species from 50% to 75% (forage fish approach – LENFEST)

Jones summarized saying it's based on a simple model of population of prey species and what the position that species holds in the foodweb. He believed this is something that could already be calculated. All it does is shift the fishing biomass to predation biomass and recommends reducing fishing to give more to the predators. It's not that different from ERPs, although the 50 and 75% might not be the correct percentages. **Butterworth** had provided this option; the MSC has been floating this, but it's a little muddled. The various ERPs were evaluated and there was a lot of variation in the models related to predator considerations. By increasing prey biomass, a larger difference was not made. However, the LENFEST study used deterministic models in a stochastic environment. The other is a Hilborn study that looked at the predator/prey relationships across numerous previous works and found the relationship to abundance of predators to prey was weak. The water temperature was more tied to predator abundance than food availability. **Jones** thinks adding an adjustment to the Biomass RP wouldn't be too hard with maybe only a slight adjustment to give a realistic buffer. **Leaf** wondered if the assessment model is fairly sensitive to B_0 depending on how far one looks back and may be dependent on whether age-0s in the analysis is included. There has to be an assumption that the environment has remained relatively static as well. If this is the case, would there be much improvement or power in moving from 50 to 75%? **Schueller** isn't using B_0 in the traditional sense. This uses fecundity. There is uncertainty around that, which could be evaluated with MCB analysis. It is not clear that changing the time period used in the model would change anything despite previous model runs using several time-series, and we already agreed to exclude the landings and composition data prior to 1977. There were many concerns over the LENFEST report and the specific computations that needed to be done. **Chagaris** noted that the report's recommendation states you need a system-specific model, which is exactly what the Atlantic has and is being done here in the Gulf. A lot of the buffer was concerned about predators that were HIGHLY dependent on a prey source, but that does not really happen here. The Gulf has a suite of generalist predators, so a buffer as high as 75% is probably not needed.

Jones moved the next ERP candidate.

Make <u>all</u> removals equal (predators and prey)

This suggested that as long as you scale everything in the environment equally (predators, prey, primary production, etc.), there won't be any other reduction because supply and demand essentially remains scaled together. There probably isn't a need to discuss this at all, because it would not be practical to implement. **Butterworth** said we've already eliminated this as a realistic option.

The next EPR was about valuation of predator vs harvest.

Valuation of dead fish (predator vs fishermen)

Jones summarized that this looks at who is more valuable as a consumer. **Leaf** reminded that in this workshop with all stakeholders, a management strategy analysis to address tradeoffs for the population and fishery is being reviewed. It's a tradeoff analysis. **Chagaris** thought this might be interesting even if not ready for consideration. This is similar to what Chagaris did for Ph.D. work on the west Florida shelf where he explored the small-scale bait fisheries. If all the species were valued equally, the model recommended harvesting more forage fish based on abundance, but once predators are valued more than forage species, the take of potential prey items should be reduced. The optimal solution comes down to how the different species are valued. **Higgins** wondered if there could be a valuation based on life history structure of prey; eggs versus juveniles versus adult in the ecosystem. Each of the age groups of menhaden may have very different values for food and reproduction. Do any of the other models capture this, if not, this might be a useful concept to consider. **Butterworth** believed that the managers can't avoid this and will eventually have to value the ecosystem components. Getting it correct will be difficult however, and the managers must have some sense of relative values.

The final ERP we had listed for consideration was addressed.

Identifying a single target predator species

Jones stated that this is related to the less complex model discussion from earlier. Is there a candidate in the Gulf like Atlantic Striped Bass? **De Mutsert** believed this would be the idea that moves the needle on ERPs. With a predator identified as critically reliant on menhaden, research could be targeted around the importance of the whole suite of prey in the system and could be used to simplify a MICE model by eliminating those species that wouldn't be critical or contributing to that predator's health and success. **Jones** wondered if there is a species more impacted by either prey removals or other ecosystem services lost by prey removal or just as bycatch? Perhaps Red Drum? **Higgins** agreed with Spotted Seatrout but believes a lot of what would move management forward would need to come from the state management plan perspective. Most of the fishery occurs in Louisiana, and both Spotted Seatrout and Red Drum are experiencing population issues in Louisiana. The State would be the appropriate place to consider the list. **T. Moncrieff** likes the current list, but Red Drum inclusion is complicated by the fact that there are very strict harvest allowances in the Gulf. He felt that species is not comparable to Striped Bass. **De Mutsert** added that she would still include those species in the MICE model even if there is a higher ranked species because the other predators and prey are still needed. **Leaf**, to be honest, felt Longnose Gar would be a species with high connectivity to menhaden that could be considered since they are essentially a specialist. **Butterworth** said he wouldn't include any other species in the MICE model if they have no meaningful impact on the model. For those included, the focus should be on the ones that are of more concern. There has to be a reason to include it. **De Mutsert** didn't know how to put a value on the 'trash fish' such as gar and that makes it difficult to include them in the model as well.

Workshop Synthesis

Jones tried to capture where the workshop was ending. It would be a reasonable conclusion that there were merits for single species RPs and a work-in-progress on ERPs. No conclusion for preferring the model-based RPs instead of the empirical-based was reached. It would be valuable to do some simulation testing to reconcile their congruency. The index-based RP might be useful in part because of its simplicity and rapid turnaround to process annually. More work needs to be done on ERPs; however, evidence at this point suggests that RPs likely to emerge from a more in-depth and rigorous analysis would not point towards very different RPs for menhaden than what is already available using the single-species approaches. More precaution in management might be suggested, but there isn't anything, given our current state of knowledge, suggesting tension in single-species RPs versus ERPs.

VanderKooy reported that there is an Operational Assessment coming in 2024. **Schueller** explained that the coming assessment will not go through a CIE review. No new, groundbreaking, earth-shattering data will be included. The ERP process will take time and would not be on the same timeline to be considered as this is an update on the assessment. **Himchak** wondered if the re-analysis of the tagging data will be considered. **Schueller** and **Leaf** both indicated that there aren't any surprises in the tagging data that would change anything. **VanderKooy** agreed with the assumption that there really isn't anything new at this point unlike when Nancy Brown-Peterson revised the fecundity estimates several years ago, which resulted in a benchmark. The more important result of the workshop is going into the assessment with better defined goals and objectives and a suite of RPs from this workshop's discussions. **Jones** believes that the group should rethink the M calculations, and perhaps, F=M should not be used unless a different value for M is used. A defensible justification for using M and the same for F to that end is needed. This is probably homework to be done. Regarding the ERPs, there is some comfort in knowing, based on out current knowledge, that the single species RPs won't be too different from ones based on ecosystem considerations. There isn't an expectation that a defensible ERP would change management significantly.

Jones added his support to the Butterworth suggestions to vet the RPs through simulations and noted would be of considerable interest if there is significant discordance between the model RPs and the EwE RPs. Again, there needs to be a trail justifying how you arrived on your RP choices.

It's probably unwise to draw too many parallels to the framework and process on the Atlantic and the Gulf. **VanderKooy** didn't think the group was even close to the Atlantic, and the Gulf Commission has not had a 'call' to develop ERPs. A dependent predator hasn't been identified like Striped Bass in the Atlantic, so there is no driver to move in that direction. **Schueller** thought even if we're not moving toward some MICE or EwE model in the near future, there are some metrics that could be used as buffers and run in projections to look at the equilibrium landings in those scenarios. The code has been used in the past, reviewed and approved, so some metrics could be explored as a 'gut check'. It is a continuum of options depending on the driving forces. **Kuttel** acknowledged that moving forward on new models and with new data, funding is needed and people to accomplish that. How do we develop those tools if that's what we need in the future? **Jones** agreed; funding and motivation is the bottom line on getting the data that's needed.

Higgins wondered about the next assessment and if it would be a benchmark for the Gulf? **Schueller** indicated that the Atlantic's single species benchmark is getting ready to start. **Higgins** suggested that perhaps the side-by-side ERP benchmark for the Gulf occurs at the same time as the next Gulf single

species benchmark. Could that occur in 2027? **Schueller** agreed that if one is being done, both should be done. It might also be the catalyst to get some of the data still needed for the Gulf EwE. **VanderKooy** noted that the Gulf Commission sits on the SEDAR Steering Committee and asks for assessments on behalf of the states and region, but not because the Commission needs it. The Gulf Commission doesn't have any hand in management like the Atlantic. The Gulf Commission facilitates for the benefit of the whole region.

Wrap-up

There will be a proceeding of this workshop drafted as quickly as staff can prepare. **Butterworth** had noted the summary at the first workshop was much more useful and absent from the second. The Workshop Accomplishments needs to be included if possible, an executive summary. The draft timeline is short, and **VanderKooy** will push to get a draft together before the end of September. **Kuttel** commended Jones on his ability to keep us on topic and moving forward. There was unanimous agreement from the participants.

Adjourn

With no further business or discussion, the workshop closed at 12:35 p.m. Wednesday.

Reference Points (RPs) in Summary

Workshop Identified Needs for RPs in the Gulf:

- Industry had developed a harvest control rule (HCR), which could be used for management. The HCR based on the indices of abundance has been tested thoroughly, and an online portal now exists to update the population indices annually.
- Non-industry stakeholders want to ensure prey is abundant enough to meet the foraging needs of predators and would like managers in the Gulf to continue to move toward ERPs
- State managers need to define the single species RPs since the understanding of menhaden biology (reproduction/fecundity) has changed significantly.
- State managers also need scientifically sound RPs that allow for the inclusion of more ecosystem considerations.
- Ecosystem modelers noted that the dynamics on the Atlantic Coast are different from the Gulf Coast. Several modeling tools were evaluated on the Atlantic Coast for the purpose of developing ERPs, while ERPs for Gulf menhaden have been developed using a single tool that needs further review in a SEDAR-like process. The current Gulf Ecopath with Ecosim (EwE) model (Berehnstein et al 2022) needs additional data to resolve uncertainties related to trophic interactions (i.e., diet data) and bycatch. The currently available diet data do not indicate any heavily dependent predators on Gulf menhaden akin to striped bass on the Atlantic Coast.
- If ERPs are desired in the Gulf, there is interest in a MICE EwE model, which would be an approach that is simpler to update on current assessment time frames. The creation of a MICE Ewe would start from the existing full EwE but would reduce the total predator and prey groups.
- There is a need to determine if any relationship exists between potential impacts from the purse-seine fishery bycatch and other predator populations that are experiencing challenges such as Red Drum and Spotted Seatrout.
- Non-industry stakeholders stated that perfect data will never be available; thus, we need to use what we currently have to move towards ERPs given the model and data are the best scientific information available.

Do we have RPs now that are sufficient for where we are now?

- We have RPs that we've spent time considering during the benchmark assessment (F and SSB RPs). We also have an index-based approach (related to the industry HCR) and ERPs derived from an ecosystem model that could be used.
- Though the current RPs have not been tested nor run through simulations, they have been considered in previous assessments and workshops and vetted by CIE reviewers during SEDAR. To determine the appropriateness of a RP, it should be simulation tested using a harvest control rule to see how it performs under a range of potential future conditions. As noted earlier (page 17) testing is required to ensure that what is believed to be an appropriate RP is not, in fact, catastrophic when applied in the real world.
- Not all the candidate RPs are 'actionable' at this time. Targets and thresholds/limits need to be actionable by management to control and/or reduce removals.

- Gulf Menhaden is not a federal fishery, which allows this group more flexibility in determining proxy RPs.

Workshop Accomplishments

1. *Review, discuss and agree on the purpose(s) for reference points.*

   The group was presented with the history of the Gulf's stock assessment and reference point development in the Gulf. A broad discussion regarding RPs in general took place relating our previous workshops discussions, and which included theoretical and empirical RPs. The harvest control rule (HCR) work covered at Workshop #2 was also discussed briefly. The history of the Atlantic Menhaden RPs from single species to ecosystem-based were provided. The current EwE model and the revised MICE model for Atlantic menhaden were also presented along with the limitations to their application in the Gulf.

2. *Evaluate the draft objective resulting from the previous workshop, and adjust as desired.*

   The group reviewed the objective developed at the first Stakeholder Workshop (February 2019) and discussed if any changes needed to be made.

   > "Balance the needs of fishery and needs of ecosystem to maintain long-term sustainability such that user groups accept shared responsibility for maintaining and improving ecosystem health, population abundance, and biodiversity and have confidence in the sustainability of the fishery, the industry, and in management."

   Out of this fundamental objective, there are a few 'means' objectives, those things that would be necessary to achieve the fundamental objective. They included:

   1) maintaining adequate SSB for recruitment,
   2) minimizing the negative effects on predators and habitat,
   3) minimizing bycatch,
   4) maintaining a sustainable commercial fishery,
   5) be able to inform management with good assessment data,
   6) allow management flexibility,
   7) consider environmental factors,
   8) maintain historic range and productivity,
   9) improve monitoring and assessment, and
   10) develop management regimes sufficient to fulfill other objectives.

   There were a number of questions regarding the effect on habitat in #2 and to what time or level we want to 'minimize bycatch' in #3, there needs to be a base starting point. Finally, there were questions about the meaning of #10. It was suggested that perhaps it was related to the management flexibility and authority that was in place at that time. Ultimately, none of the objectives were changed and the fundamental objective was considered acceptable and appropriate.

3. *Review the current status of the fishery (GDAR 03).*

   The last update assessment from 2021 was reviewed and the benchmarks explained. There was a lengthy discussion regarding how the benchmarks of F and SSB were derived and changed over time. A new benchmark assessment was conducted in 2018 through the SEDAR65 and the reviewers at that time noted concerns over the RPs but agreed that in the absence of MSY, they were acceptable proxies.

4. *Review previous candidate reference points and discuss their merits and disadvantages.*

   The group explored the previously recommended candidates and offered a few additional options. Those RPs included both single species and ecosystem-based approaches. Each was discussed and the pros and cons of each were considered. In the end, the single species, model driven RPs were the most likely candidates but it was agreed that some metrics from the ERPs could be incorporated or at least explored including potential buffers for ecosystem services. It was also noted, importantly, that the preliminary evaluation of ERPs suggested target fishing levels that are not very different from those emerging from the single species RPs. Nevertheless, much more work will need to be done with regard to the ERPs before they can be applied in the Gulf.

5. *Design an implementation process for selecting among candidate reference points.*

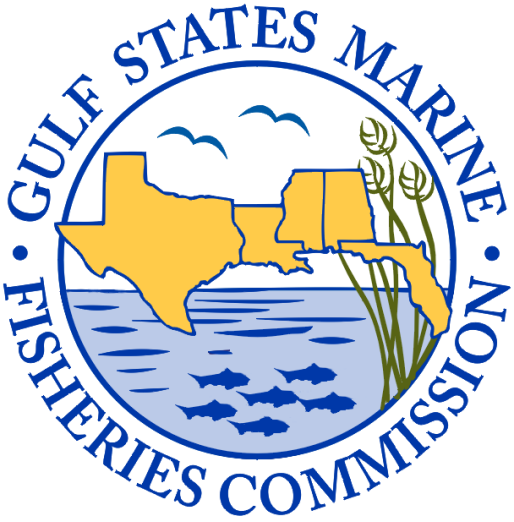
   The discussion regarding implementation was more about how to consider the suite of options in the upcoming stock assessment update. Upon completion of the assessment, the most likely candidates will be vetted and the Menhaden Advisory Committee will ultimately select the best RPs for potential management to present to the Commission. The moving of those reference points forward will become options for the state agencies to consider for adoption.

Research Recommendations

1. Explore development of a reduced EwE model similar to the MICE model on the Atlantic. In selecting key predators/groups that should be included, the group recommended keeping Red Drum and Spotted Seatrout as well as considering others such as Sharks, Mackerels, Bluefish, Crevalle Jack, and if possible, Brown Pelicans although not all have population assessments. In addition, more prey could be included however assessments don't exist for any other than menhaden. The modelers would need to work with the MAC to better define the species included.

2. Simulation test any of the RPs being considered in the assessment before application for management.

3. Consider running a benchmark/research-track BAM assessment for Gulf Menhaden in 2027/2028 alongside an EwE assessment to push the process along and encourage the research needed to fill in the EwE parameters.



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