

WORKSHOP TO ASSESS OPTIONS FOR MANAGEMENT REFERENCE POINTS FOR GULF MENHADEN FISHERIES

HOSTED BY

GULF STATES MARINE FISHERIES COMMISSION

FACILITATED BY

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FEBRUARY 12-13, 2019

**FOUR POINTS BY SHERATON FRENCH QUARTER
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The complete two-day workshop video is available on the GSMFC YouTube channel at :

[**WORKSHOP VIDEO**](#)

WORKSHOP TO ASSESS OPTIONS FOR MANAGEMENT REFERENCE POINTS FOR GULF MENHADEN FISHERIES

February 12-13, 2019
New Orleans, LA

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Welcome and Introductions

VanderKooy provided some housekeeping notes related to travel and other items and introduced **Dr. Mike Jones**. Jones is a professor at Michigan State University and codirects the Quantitative Fisheries Center. Jones has done work in the Great Lakes as well as the Pacific Northwest including Alaska. He has a long history of facilitating workshops like this. Four years ago, **Jones** facilitated the ecosystem

management goals workshop for Atlantic Menhaden on behalf of the ASMFC and was an academic advisor for Dr. Schueller when she was a student at Michigan State.

The participants introduced themselves and provided a little of their background.

Approval of Agenda

No changes were recommended on the agenda and **Jones** indicated that items may be moved around depending on how discussions progressed.

Overview of Process and Workshop Goals

Jones provided his expectations for the workshop and the plan moving forward. His take was that this group should:

- discuss the purpose(s) for reference points,
- identify candidate objectives for the fishery,
- review the current status of Gulf Menhaden and the fishery,
- assess candidate reference points, and
- discuss management implications.

Jones explained the process to proceed. All ideas are welcome. Jones will use flip charts to capture the key points as they are provided so we can track how the discussion is evolving. The audience is free to raise questions for clarification as the process moves forward. There will be time for public comment in general and rather than waiting until the end of the day, we will provide an opportunity for comment after each of the respective agenda items so as not to delay potential input.

Finally, in an effort to maintain decorum for discussions, **Jones** reminded everyone that there will no doubt be differing points of view and we should work hard on the problem and not the people. Be mindful and respectful of each other as we work together. We need to distinguish between ideas that reflect values as opposed to those which are interpretation of evidence. Keep comments as concise as possible. While many of the participants are scientists, we will try to avoid getting bogged down in the minutia of details that don't actually help the discussion.

Role of Reference Points in MSC Certification of Fisheries


Marin Hawk and **Pippa Kohn** (presenting remotely) summarized the general procedures used by the MSC and how various fisheries are assessed. Hawk is the Fisheries Outreach Manager and works with the fisheries going through the certification process. MSC is a global program with multiple facets, including fishery certification, chain of custody or traceability, and ecolabeling. It is a market-based program which utilizes its ecolabel to recognize sustainable business and fisheries. Interested entities voluntarily go through the assessment process, which is conducted by a third-party, independent auditor. Fisheries are assessed on three principles, stock status, ecosystem impacts and management systems, with twenty-eight specific indicators falling under those principles. Each of the twenty-eight performance indicators must score at least 60 and the average for each of the three overarching principles must be an 80 to pass an assessment (Sustainable target fish stocks, Environmental impact of fishing, and Effective management). Any performance indicator that is scored below 80 must work up to an 80 (considered best practice) during the life-span of the certificate (a five-year period). Every year the fishery undergoes a surveillance audit to ensure no significant changes in the fishery have

occurred and to track progress on any raised conditions. If a significant change in the fishery is detected either through an annual surveillance audit or an expedited audit which results in a finding that the fishery no longer conforms to the MSC standard, dropping below the 60 minimum score, the certificate can be suspended. If that occurs, the client must adopt an improvement plan to bring the performance back into conformity to allow re-instatement of the certificate.

Kohn is on the Science and Standards Team for MSC and discussed the minimum Reference Points (RPs) that would be expected under MSC. For the determination of stock status, two scores are considered, the point of recruitment impairment (PRI) and MSY. The differences between the scores reflects the level of certainty that the stock is above the PRI.

The default values (see text box) are identified for species with average productivity. A species like a forage fish or a very slow growing, slow maturing species may require different values; such differences must be justified analytically. The use of proxies is allowed in the program for species that might not fit typical MSY-based RPs. Because MSC is a global program, the use of proxies is flexible to allow a diversity of countries and fisheries to participate and be able meet PRI requirements. Examples used elsewhere include CPUE or LPUE (=landings; crustaceans), mean fish size for exploitation level, and historical state at an unexploited level. F (fishing mortality) is also allowed as a proxy. If you use F, the scoring is related to the length of time F is likely to have been at or below F_{MSY} . In summary, the RPs must be appropriate for the fishery, and the MSC standard also takes into account uncertainty, the harvest strategies and control rules, and if the assessment and management process has been peer reviewed and shown to be robust and rigorously tested.

Default values for the levels of the PRI and B_{MSY}


$$B_{MSY} = 40\%B_0$$
$$PRI = 20\%B_0 = \frac{1}{2}B_{MSY}$$

- If values have been analytically determined, those values should be used as the reference points for measuring stock status unless additional precaution is sought.
- The default PRI values given above apply to stocks with average productivity. For short lived stocks the PRI may be lower whereas for longer lived species it may be higher.
- Further detail provided in the MSC Guidance

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Kohn next discussed low trophic level (LTL) species characteristics like menhaden. The LTLs generally have a small body size, exhibit rapid growth and schooling behaviors, have strong population responses to environmental variability, and provide an important ecological role specifically as transfer of energy from low to higher trophic levels. Some LTL stocks are classified as Key LTL (see Box SA1) when they are found to play a key role in the ecosystem or it meets multiple criteria identified in the Standard (see [MSC Fishery Standard Guidance Document](#)). Species not included in Box SA1 can be determined to be Key LTL if two criteria AND the species is a planktivore, small, shortlived, etc. LTL species are assessed as outlined previously, with those stocks identified as key LTL generally having

higher management requirements because of their role as forage species, and are therefore scored regarding potential serious ecosystem impacts. The default target biomass for key LTL stocks is identified as 75%(B₀) but can be lower if justified through either credible ecosystem models or robust empirical data, that there are not adverse impacts at both the ecosystem and individual species levels.

Box SA1: Species types that are defined by default as “key LTL stocks” for the purposes of an MSC assessment. ■

See ASFIS List of Species for species included in different families and orders (<http://www.fao.org/fishery/collection/asfis/en>)

- Family Ammodytidae (sandeels, sandlances)
- Family Clupeidae (herrings, menhaden, pilchards, sardines, sardinellas, sprats)
- Family Engraulidae (anchovies)
- Family Euphausiidae (krill)
- Family Myctophidae (lanternfish)
- Family Osmeridae (smelts, capelin)
- Genus Scomber (mackerels)
- Order Atheriniformes (silversides, sand smelts)
- Species *Trisopterus esmarkii* (Norway pout)

Allowing for F as proxy to score stock status is only determined in a single species context. A default of 0.5 M or 0.5 F_{MSY} can be used where these quantities have been determined. These values can vary but would need to meet the same ecosystem and individual species requirements that would apply for biomass-based reference points. For Key LTL species, proxy fishing mortalities must be adequate to maintain the stock above the point where serious ecosystem impacts could occur and may be lower than what is assumed necessary to keep the population above the point where recruitment would be impaired (PRI).

Kohn and **Hawk** entertained questions. **Dix** asked how many of the MSC fisheries actually don't have catch limits and if the Gulf fishery would be viewed as data limited. **Kohn** could not make a data limited determination seeing as they are not involved with the actual assessment, it is being conducted by SAI Global, the third party assessor. **Leaf** assured everyone that the Gulf fishery is not data limited.

Jones asked what the primary reasons for going through MSC were. Often it's for increased market share, reduced management and oversight. **Landry** explained that its market driven for access to buyers looking for the sustainable product in the global market.

Hansen was curious about bycatch monitoring under MSC certification. What data on bycatch is required for or after certification? Obviously bycatch and indirect impact on other species and the ecosystem are part of the assessment process for certification. **Kohn** indicated that there are times when additional data collection may be required in the Client Action Plan. Depending on the scoring by the assessing body of that particular indicator, if the score is below 80, additional data collection will be required to raise their score and maintain certification in the future.

Leaf asked if any RPs have been put forward as proxies which are NOT useful and have ended up being discouraged by MSC. **Kohn** indicated that they don't have a 'list' because it's hard to generalize that

any proxy would be inappropriate under all circumstances. Options need to remain open, so no, there is no list of RPs to avoid to help this group moving forward.

Discussion of Objectives for Management

Jones went through the broad approach to Structured Decision Making and how to define objectives that reflect stakeholder values for a decision problem, such as management of a fishery. It is critical to have well-defined objectives which are articulated well. Without objectives, it is impossible to determine which choice is the best choice. **Jones** explained that in general there are two types of objectives, 'fundamental' which are the broadest objectives – the 'ends' for a decision process – and 'means', which are the things you need to achieve to get to the fundamental objective. All objectives need to have measurable attributes or performance measures to help management determine WHETHER they have met the objectives. For our purposes, Reference Points (RPs) – are examples of measurable objectives; they are used as an indicator of success/accomplishment.

Brainstorm Range of Management Objectives

Jones asked the group to begin to discuss what an overall objective should be or could be for the Gulf menhaden fishery. There will not be just one and there likely will be objectives that conflict with others. The purpose is not to agree on the right set of objectives but to have objectives that reflect the needs identified by all the user groups for the fishery, the population, and the environment. **Jones'** fundamental objectives could also be called goals and the means objectives define the way to achieve the goal. **Jones** asked each participant to take a moment and right down what they see as the primary objectives for the Gulf menhaden fishery, which can be social, economic, and/or biological.

Jones recorded individual responses to look at overall commonality. As the panelists offered their suggestions, many responses were similar and reflected a number of common concerns. The majority were means objectives but there were some overarching fundamental goals.

Common terms that were repeated throughout most were *optimizing biomass, long-term sustainability, monitoring, and assessment*. The group followed up with additional items such as *avoiding negative environmental impacts and maintaining biodiversity*. **Jones** wrote each person's objectives to explore the commonality for one overall fundamental and combinations which would form the second tier of means objectives. The complete list can be found in Appendix A.

There was a question about how these objectives fit into the current FMP which has its own goals and objectives. **Jones** indicated that the idea of this workshop is to see where the discussion takes us. It may or may not lead to a new management plan but the Commission is providing the opportunity for stakeholder input on the future of management. If successful, agreement on more comprehensive objectives would allow the resource agencies to potentially move forward with improved management strategies in the future. **Chagaris** pointed out that many of the objectives we are discussing are more hypothetical in nature since the Gulf Commission doesn't really manage the fishery, unlike the Atlantic Commission. There is a need for more practical objectives for the states to manage the resource. Many of the objectives are crossing jurisdictions. **Jones** would like to see the overall objectives and many are very general as they relate to fisheries but a number are directly tied to Gulf Menhaden. Looking over everyone's contributions, the need for balance is the prevailing theme that comes through. There aren't any that say provide maximum employment or value back to industry investors. Everyone in the room is clearly aware of the species and ecosystem needs. There may or may not be conflict between

sustainable commercial harvest and a sustainable ecosystem. As we drill down further, those issues will become more evident.

The first objective provided seemed to be the most fundamental and captures the overall concern well:

Balance the needs of the fishery and the needs of the ecosystem to maintain long-term sustainability.

This is inclusive of the other objectives, particularly if ‘people’ are considered part of the ecosystem, which would thus include public well-being in that concept. At this point, a number of the primary elements for additional objectives seem to be in place. These include a number of what **Jones** considers means to get at the fundamental objective but would ultimately need considerable wordsmithing to get something finalized for use in a management plan but for now, seem to cover all the bases. **Jones** recommended moving on with the agenda at this point to provide more information to help the group refine their thoughts on the objectives and move toward a discussion of RPs as they relate to the objectives already provided.

Gulf Menhaden Benchmark Assessment Results

Leaf reviewed the results of the benchmark and addressed several questions related to natural mortality. This is a single species assessment and doesn’t take ecosystem data into direct consideration. He particularly pointed out issues and questions raised by the reviewers which may help us when working on the RPs. **Leaf** ran through the data that was used to derive the indices included in the assessment and the overall model structure. The group spent considerable time discussing uncertainty around M and how mortality was derived. Generally recruitment and mortality scale the outputs of the model so relative abundance was lower during the heavy exploitation period in the 1970s and 1980s and higher in the last two decades. Fecundity is used as a proxy for spawning stock biomass. A couple of the sensitivity runs were found interesting to the reviewers. When we change our estimate of length-specific natural mortality estimate, the total mortality results in a depressed fishing mortality – the converse is true at lower natural mortality. **Landry** wondered if predation mortality could be teased out of the Lorenzen model. **Leaf** responded that no you can’t, total mortality includes all forms of mortality. **Chagaris** indicated that some ecosystem models are able to address this a little but it’s not a simple effort. His presentation will include some of that discussion later.

Recruitment in general has been high the last several years but the gillnets which provide the adult index show a lot of variability and the low recruitment value in 2008 is just the model trying to catch up with it (below). Commercial catch is not a good measure of the relative abundance in the environment. The landings also reflect the effort in the fishery and not necessarily changes in overall abundance which is why we derive the abundance indices from fishery-independent data. **Adriance** reminded everyone that there is a lot of noise in the independent data since there a number of environmental drivers which contribute to the fluctuations such as rainfall, river discharge, tropical systems, etc.

Ageing error was another item the reviewers were interested in. The age of the harvest is conducted using scale ages. The age composition is heavily relied on for characterizing the population. Error occurs about 20% of the time and will need to be followed up in the future.

Hansen asked why we go back to the 1970s in the model and don't go back further when the fishery has been around since the early 1900s. **Leaf** explained that there are good fishery independent data only since the 1970s. The model needs that info to make the estimates. When the model is run further back, even to the beginning of the fishery, there wasn't any change in the estimates for more recent years. The reason is that the recent history has had a lot of contrast in catch from extremely high to much lower. The 1977 data series forward includes that period of high contrast so the model doesn't need the additional earlier years to arrive at good estimates for the more recent years.

Public Comment

Following the presentation, **Dr. Jerry Ault** noted that the intrinsic value of menhaden needs to be considered and the goals need to acknowledge that. There are a number of migratory fish that pass through the menhaden population and rely on them during their migration which could be missed in routine sampling. Tarpon rely heavily on the menhaden plume during this time and they need prey to build their fat reserves to make that migration. One of **Ault's** primary concerns is that BAM is a forward projecting model and it is biased. How do you scale the model? If you want B_0 (virgin stock) in the model, it is not represented by starting at 1977, there has been fishing since the late 1800s. When it comes to RPs, current harvest should not ever achieve MSY, MSY should be the limit. Beyond MSY, the population drops quickly and you wouldn't want to go there. Let's be conservative and make good decisions.

Lunch Break

While waiting for the return of a couple participants from lunch, **Jones** wondered if there was agreement that the decline in abundance (SSB) in the 1970s was tied to fishing levels at that time. **Leaf** and the states agree. Coincidentally, there was a shift in the age composition of the catch around that time as well moving from age-1 fish to age-2. The age shift of those fish at the break point was validated by revisiting the scale samples and they found it to be correct. **Mareska** believes that Doug Vaughan (Schueller's predecessor) found a similar shift along the Atlantic. **Leaf** noted that we explored multiple time blocks around that shift in SEDAR32 but it wasn't able to be explained so we went with the single block starting beyond that shift. The industry did not make any changes to explain the shift, it's just one of those unknown issues that has come up and is an unknown.

MSE Analysis of Reference Points for Gulf Menhaden: An Initial Illustrative Example

Leaf and **Himchak** provided an overview of the report provided by Drs. Doug Butterworth and Rebecca Rademeyer for consideration in the Gulf Menhaden RP development. Butterworth and Rademeyer evaluated a harvest control rule (HCR) that responds to reductions in indicator indices. Their example uses a technique called management strategy evaluation (MSE) which is a method using simulation modeling to account for uncertainty in management and evaluate trade-offs of various management strategies. It allows one to assess alternative strategies and determine their robustness. They developed a candidate HCR for Gulf Menhaden that would ensure a *very low probability* of abundance falling below some pre-determined historical level, as measured from an index that combines both fishery-independent surveys used in the BAM. Their aim was to satisfy MSC Certification requirement by allowing for sustainable exploitation while factoring in ecosystem considerations.

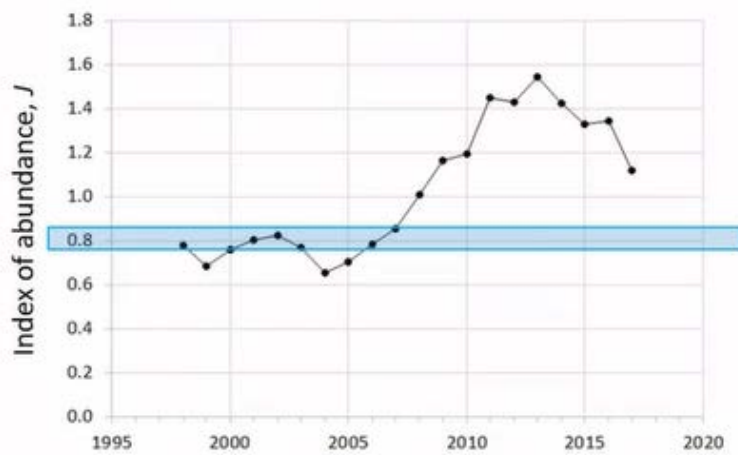
They proposed that the 1992 estimated level for SSB is probably the level that we don't want to reach or fall below again – any HCR should aim to keep the population above this level. This begs the

question of what was the cause of the decline in abundance historically, and how do we avoid it again? **Jones** was curious if there are any documented undesirable ecosystem consequences of the population being this low? Is there evidence of any impacts negative or not? **Hansen** wondered if there is evidence showing no impact or just no data (i.e., evidence of absence versus absence of evidence)? **Leaf** suggested that before we get wrapped up in any specific years or points on the graph, we need to focus on what points ARE potential candidates. This simulation example presented by Butterworth and Rademeyer simply picked a minimum value in the time series as an example. Everyone agrees that there IS some value which is critical but we need to figure out what that is, ideally with some data to provide evidence in support of it. Regardless, the utility of the MSE process to explore RPs does not depend on the specific limit we chose to consider.

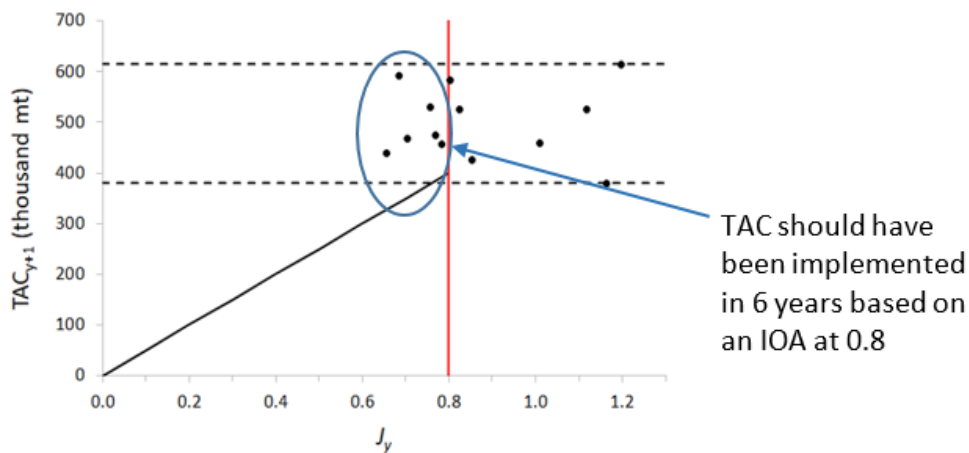
Dix asked if there is any other resource we know of in the natural world that has experienced relatively high extraction, but without an impact on the environment. **Himchak** pointed out that 'high' is relative... looking back to 1977, the stock has been very resilient and has indicated it has been able to sustain those levels and increase to today at a level of fishing that represents a lower extraction rate.

Chagaris noted that in 1990 many of the predators on menhaden were likely reduced in abundance, which would reduce the likelihood of ecosystem impacts (lower predation pressure) but now that predators are more abundant, maybe comparable levels of prey abundance could impact the system. **Chagaris** concurs that the point selected was more as a matter of convenience rather than the importance of that particular year. The process needs a point to be used as an example. **Jones** reminded everyone that you need an HCR so all we are doing is arguing over the appropriate level, not how to implement one. The number isn't as important, it's just an illustration.

Himchak showed the operating model with landings back to 1962. Projection of the operating model was reviewed. Butterworth and Rademeyer based future dynamics on past recruitment patterns (1978-2017) as estimated from the BAM base model and made thousands of projections based on randomly selecting from 2000-2017 landings, which does reflect current fishing effort. The combined index (LA gillnet and three states' seines) was smoothed and examined over the same 18 year time period. This is an example of an index-based RP, with a trigger value for the index of abundance (IOA) of 0.8 (see figure below), which represents a value typical of the early period (1998-2007).



Himchak continued and displayed how the candidate management rule would be applied. The proposed trigger for the index, J_y , of 0.8 means that when this observed index drops below the trigger, a TAC reduction would be implemented, relative to recent landings, that would be directly proportional to the ratio of the observed index to the trigger value. The figure below shows this, with the proposed trigger of $j=0.8$ as a vertical red line. The expectation is that when the index declines below 0.8, a TAC would be applied to reduce harvest rapidly that would allow the stock rebound and return to optimal SSB levels. According to the example, about 6 years in the last 20 would have been problematic as the index was below 0.8 (to the left of the red line). **Leaf** walked through the construction of the simulation and acknowledged the uncertainties and assumptions in the model. He suggested that, as a strawman, it's a good model for us to consider and explore.



In the base scenario examined by Butterworth and Rademeyer, how well did the candidate HCR work? The projections continue to 2040. Performance testing lets you know how often the HCR is implemented incorrectly, i.e., was a TAC applied when it should not have been (false positive) or not applied when it should have been (false negative)? Butterworth and Rademeyer looked this and found that the 0.8 trigger resulted in a correct decision about the TAC around 93% of the time.

This is potentially a useful tool to assess candidate HCRs and RPs in 'what if' situations. The HCR could be implemented in the same year and the index is measured, lagged a year, or rely on a multiple year lag approach. The projections could allow you to also explore not turning on the HCR and seeing what happens in subsequent years. Sensitivity to assumptions can be evaluated, just as they were in the BAM benchmark assessment.

In general, the performance of the HCR and associated RPs is indicated by the degree to which management objectives are met over the projected time series. The RPs examined in this example are not MSY-based; they only require continued collection of the current fishery-independent data. MSE can be used to evaluate any number of RPs, not just the one used in the example.

The validity of this approach (base RP on historical index levels) rests on the premise(s) that remaining above these threshold levels of abundance will not lead to deleterious ecosystem effects. If abundance

can be maintained above its lowest level historically, it is assumed that ecosystem problems should not arise. The validity also rests on the assumption that the IOA continues to track reliably track the actual abundance.

The next steps in model development should be to explore the use of different operating models and different projection assumptions, the interpretation of robustness or performance of test results, and coming up with alternative management rules.

Jones indicated that this presentation sets the stage for discussion of potential RPs and that the MSE approach could be used to evaluate ANY potential RPs. The simulation methodology is a great approach to determine the effectiveness of those RPs we might consider. **Jones** suggested a change to the agenda to have **Mareska** and **Chagaris** make their presentations today rather than tomorrow to get all the information on the table before discussing options for moving forward.

Dix wondered generally if the removal of menhaden has had any effect on hypoxia in the Gulf and the dead zone. Is there any tie between the dead zone and menhaden fishing? **Landry** and **Himchak** indicated that work in the Chesapeake showed no reduction in hypoxia by menhaden removing nitrogen from the water. Menhaden have been found to actually add nitrogen in plumes around large schools as a result of feeding and their waste products so there may not be any real benefit of higher menhaden abundance in this regard. In the Gulf, menhaden generally move out of the hypoxic zones because they are equally as negatively affected as other finfish species.

Break

Presentation of Candidate Benchmarks/Reference Points

Mareska provided a history of the various benchmarks that had been discussed over the history of Gulf Menhaden assessments since SEDAR27. **Mareska** began with SEDAR32. At this time we did not establish any specific goals or objectives and SSB RPs were not adopted. We discussed that habitat loss in Louisiana may have contributed to uncertainty in our recruitment estimates and SSB was based on relatively old fecundity data. Instead we derived F-based accountability measures based on historic landings and F estimates based on equilibrium yield. Assessments were triggered if the SPR target was exceeded in two consecutive years or the SPR threshold was exceeded in one year.

In the most recent benchmark assessment, SEDAR63, we had proposed target and threshold using fishing mortality (F) estimates based on the geometric mean of natural mortality (M). Corresponding SSB values based on F produced an unstable metric for management that fluctuated unrealistically between overfishing and no overfishing. Instead, we derived an independent estimate of SSB using an *ad hoc* approach and settled on 50% and 25%SSB₀ but they were implausible and abandoned.

Mareska also discussed RPs we considered but did not adopt starting with SEDAR32 in 2013. We explored ecosystem based RPs but there wasn't enough information to support an ecosystem model. F_{med} was considered based on the Atlantic stock. This approach allows for annual variation in recruitment assuming wide-ranging environmental conditions but the Gulf's stock-recruit relationship was weak. F_{target} was considered *ad hoc* based on simply selecting something between the target and limit. The REPASt control rule suggested by Prager et al. (2013) set RPs based on precision estimates related to the assessment but the level of risk acceptance by managers wasn't satisfactory which is still

a problem since the state agency managers can't set policy. We considered another *ad hoc* approach to construct a stock-recruitment curve but it wasn't a strong candidate either.

Z-based RPs were discussed which used catch-at-age data to develop a time series of Z. The issue with this was that we had increased recruitment in recent years that led to increased catches so the three-year moving average would have exceeded the maximum in the recent time series creating an unstable management situation. Other RPs were considered which were index based such as those suggested by Whiting PDT (2011) and another by Gabriel and Mace (1999). Each had its own issues when applying to a spotter driven fishery or required an estimate of F_{MSY} which could not be estimated. Additional models included Cox et al. (2015), Zhou et al. (2012), Hilborn (2002), and Froese (2004). Ultimately we determined the best approach is to use RPs derived from outputs of the BAM model.

Following the current benchmark assessment, the CIE reviewers made several recommendations to help us develop objectives and RPs. In the short term, the recommended exploring historical based RPs and in the long term, use simulations and the MSE process to look at potential RPs and evaluate their performance. The reviewers did not believe that the proposed F and M-based RPs were appropriate and thought them to be crude. They did suggest a B_{lim} method which formulates advice on the probability of a SSB level below which recruitment would be impaired. No one really knew what B_{lim} involved. **Chagaris** looked it up and explained from the ICES document – it's the biomass below which a stock is considered to have reduced reproductive capacity. **Hansen** wondered if there was an exercise during the assessment process to look around the world in the literature at RPs that were used in other similar species to see how effective they were. **Leaf** stated that all the models **Mareska** just provided were examined for potential. One of the challenges in forage fish RPs is that many of these methodologies required that preseason surveys be conducted to inform the model, either acoustic or egg surveys, and we didn't look at the performance of them due to the index that would have been required. The most useful was a paper **Mareska** alluded to which was Hiborn (2002).

Himchak reminded that the F=M RP was originally suggested by Dr. Jeff Short but was actually derived for rockfish, not for herring or forage fishes. The reviewers agreed that this was probably not transferable and we have moved away from that suggestion as a potential RP for a forage fish in general.

Jones asked **Hawk** if there anything remotely similar to menhaden that could be looked at which might be similar enough to at least explore? **Hawk** reminded that **Kohn** had listed a few on the presentation which included anchovies and others. **Hawk** would be happy to provide a better overview of that list. **Hawk** might be able to look into a couple of species which could be further explored? **Jones** believes it would helpful to have similar species and fisheries – it's all on the table but it would be beneficial for the discussion. **Leaf** suggested that **Mareska** did do a pretty good job covering most of the models that were available for forage and/or planktivorous fishes. We would be surprised if there was actually more out there but it would be good to double check. **Landry** agrees that the exercise would be helpful but as **Leaf** indicated, we've sort of looked and this is what we found. Gulf Menhaden shouldn't be pigeonholed into another fisheries situation just to force a fit. A considerable amount of brainpower went into the assessment for our fishery here in the Gulf and it's not likely that something like Peruvian Anchovy would match well enough to replace what we've already done here. **Himchak** agreed and noted that in a conversation with Mike Prager, there just aren't any other species in warm water that are short lived that match up that well. **Hansen** understands and agrees that looking at somebody

else's RP just because its available isn't necessarily good but if there are performance indicators that suggest they may have some utility, that would be useful information to have.

Jones' take away on the general RP discussion was that over the course of all the SEDAR discussions, there was an interweaving of theoretical-based RPs (MSY, etc) and index-based RPs. Survey indices have been considered so that the strawman Butterworth and Rademeyer provided is actually part of the suite you have looked at in the past. While in the SEDAR report you weren't entirely comfortable with recommending an index-based route, there should be more optimism about potentially using one since MSY based RPs almost certainly don't make sense for this species.

Hansen wondered about the gillnet survey if we are taking about an index-based RP. What is the comfort on the survey and is there something that needs to be considered for improvement or continuation? What does the variability in that index mean? **Leaf** reminded that we have a number of other data elements for potential use as indices from all five of the Gulf states. **Adriance** indicated that the Louisiana Gillnet has changed over time and it might change again. Is it still a good index? Yes. **Hansen** asked if the CIE reviewers suggested anything to improve the surveys or are they standardized enough to be combined and used as one single index. **Leaf** noted that while there are some minor differences between the states gears and methodologies, most of the indices have been standardized to each other. We are just consumers of the data and prescribing changes or improvements to the sampling design was not in our purview. The state surveys are not designed to target any species in particular, they were originally intended to simply catalog long-term trends in all species abundances. The gear are not designed to target menhaden, they are essentially an incidental catch but are consistently caught incidentally. **Chagaris** wondered how we got to index-based monitoring. We don't have a data limited scenario but we could use the assessment estimated biomass and monitor the stock on a more regular basis. **Leaf** responded that we might be here because the SPR-based RPs don't seem reasonable right now. Some measures derived in the assessment won't pass peer review again. Hilborn argued that IOA does track well and maybe returning to some first principles would be good. The use of observed data has some benefit over modeled data trends. **Jones** also noted a distinction between a method that is a benchmark of the status of the population derived from historic levels as opposed to calculating the theoretical values. The J index presented in the Butterworth and Rademeyer paper is actually closer to the real data than the BAM estimate of SSB. **Moncrief** asked about the possibility of using the historic landings AND the surveys themselves as a combination of fishery-dependent and -independent index. **Leaf** thinks that might actually work for something like CPUE. **Jones** reminded that there may be an issue with hyperstability in the fishery – even when population abundance is declining catch may remain artificially high because the fishery is spotter driven, and therefore efficient at targeting large schools. **Chagaris** concurs that something more index-based could provide you a quicker annual view of the population.

Ecosystem Modeling Considerations for Reference Point Development

Chagaris presented several eco-based models which are being considered for Atlantic menhaden and have potential for application to the Gulf. **Chagaris** is a member of the ASMFCs multispecies working group. The 2017 ASMFC Amendment 3 called for adoption of ecosystem-based reference points (ERPs). The group spent considerable time evaluating the Lenfest ERPs (Lenfest Ocean Program: <https://www.lenfestocean.org/>) and found a lot of issues with conversion to age structured currency that didn't really work with Atlantic menhaden, so they were uncomfortable moving them forward. The group developed similar management goals and objectives to what we came up with here at the

start of their process. These included maintaining prey to support predator targets, sustainable harvest, economic value relative to predator value, and improving the menhaden age structure in the population.

Chagaris provided a matrix of ecosystem-based model options developed by the ASMFC group and ticked off the specific objectives each model was able to address. The third column is probably key in that it relates not only prey biomass but also predator biomass target levels; predators are part of the overall equation.

APPROACH	POTENTIAL MANAGEMENT GOALS/OBJECTIVES							
	Low disease prevalence	Adequate nutrition levels	Enough prey to support key predator species @ preferred biomass levels	Sustainable AM fishery in light of forage pressure	Better AM recruitment and/or high AM abundance at younger ages	Determine if AM are more economically valuable in the fishery or as forage	Sustainable AM commercial reduction and/or bait fisheries	Manage for a broader-age structure (may lead to re-expansion of historic range)
Ecosystem indicators	x ¹				x			
Nutrition Ref Points	x ¹	x ²						
Production models								
Steele-Henderson			x	x			x	
Time-varying r				x			x	
Single-species models								
BAM-based forage services ERPs				x	x		x	x
BAM or SS-based time-varying M tuned to consumption index				x	x		x	x
BAM-based MSE				x ³	x		x	x
Multi-species models								
MSVPA or MSSCAA + BAM projections			x	x	x		x	x
MSSCAA			x	x	x		x	x
Ecopath with Ecosim			x	x	x		x	x

Chagaris discussed five models, from the most simple to the most complex, which included a basic surplus production model, the Steele-Henderson model (four predators), a multispecies statistical catch-at-age model (five species included), the Northwest Atlantic Continental Shelf (NWAC) Ecosim Model (61 functional groups from detritus to mammals and birds), and a highly simplified version of NWACS EwE models of intermediate complexity (MICE), that latter of which **Chagaris** himself is evaluating (includes only phytoplankton, zooplankton, benthos, menhaden, and a few predators). Generally speaking these models show that if predators are fished at high levels and in need of rebuilding as they were in the early 1990s, the effects of fishing on prey is less noticeable, because predator demand is low. When predator biomass is increased, the potential to see negative impacts is greater. When both are varying simultaneously and at least somewhat independently, forecast the impacts is very challenging. Most of these models are using Atlantic menhaden-specific data, not borrowing from Gulf menhaden. The timeline for these models to be ready for an assessment workshop on the Atlantic is this coming summer; work on the model began in early 2018.

Chagaris then reviewed the current Gulf models. There have been at least 45 ecosystem models developed over the last 35 years ranging from simple conceptual models to highly complex Ecopath/Ecosim models with a few developed specifically for menhaden. **Chagaris** and several others are working on a RESTORE (<https://www.restorethegulf.gov/>) funded project to adapt multiple ecosystem models for use in the Gulf. They integrate stressors and predator-prey interactions and include Gulf Menhaden.

The MAC has heard presentations over the last year on a few of these modeling efforts. One Gulf Ecopath model is being developed by Skyler Sagarese at NOAA. Kim de Mustsert is wrapping up a Northern Gulf of Mexico (NGOMEX) model looking at coastal Louisiana and ties in hypoxia, and **Chagaris** has a model focused on reef fish on the West Florida Shelf (WFS).

Sagarese's Gulf Ecopath model includes 76 functional groups and focuses on federally managed and Highly Migratory Species (HMS). It incorporates a diet matrix, discards, and flows through menhaden (ages 0-4+). In the published report the model is called a Gulf Menhaden model but in fact it is a 'clupeid' model and includes all predators which could potentially consume menhaden based on their reported diet of similar, menhaden proxy species. Diets for this model were pulled from outside the system because there just wasn't any localized diet data. In general, predators in the Gulf are less reliant on menhaden than they are on the Atlantic because of a greater diversity of alternative prey. It was noted that the figure from Sagarese's paper that **Chagaris** showed doesn't include Tarpon but probably should. The model also includes bycatch data that came directly from the purse seine fishery in the Gulf (Guillory and Hutton 1982, de Silva et al. 2001). At this point, the model is being calibrated in Ecosim from 1980-2017. Environmental data being used include chlorophyll-a, Mississippi River outflow, etc. Mustsert is linking some of her data into this model as well. The group expects to have most of the work completed and plan to present a final draft to the MAC in the fall or next spring.

Mustsert's model (NGOMEX) ranges from Galveston, Texas to Pensacola, Florida with 60 functional groups. She has added age structure to menhaden. It's helpful because it includes the center of the Gulf Menhaden range and explores a lot more potential environmental drivers of nutrient enrichment. The model includes spatial/temporal dynamics of menhaden biomass. In general, these models have not been spatially validated in a formal statistical manner. Ideally, the group would work directly with the industry for validation.

Chagaris's model focuses on commercial and recreational reef fish and includes 83 functional groups with age structure. Ecosim has a policy optimization option so that the various fishing fleets are linked through the food web interactions. Growth in one fleet may reduce the productivity of another fleet. It also allows optimization of profits through socio-economic criteria, ecological criteria, and mandated management goals for biomass such as rebuilding efforts.

At this point, **Chagaris** is still unsure what the ERPs will look like on the Atlantic. The Gulf models are not ready for the MAC yet but they should have something to present by the fall.

Himchak stated that the ASMFC has invested a lot of time and funding into multispecies management so considering this investment over the last twenty years, and considering the potential goals and objectives we came up for the Gulf fishery, how far away are we to getting to ecosystem modeling inputs for our region? **Chagaris** said we are catching up very quickly but data uncertainties are not going away. Any reporting that occurs will acknowledge these issues. They are not ready to be used in management at this point but **Chagaris** suggested we re-evaluated where the models are in a year or year and a half. We may not have the suite of tools they have on the Atlantic but we may have some that we can apply in the Gulf based on what's been done on the Atlantic.

Dix wanted to go back to the MSC discussion - is the Gulf data limited? Do we have the data we need to understand the fishery? **Chagaris** reported that the menhaden fishery is data-rich but the data gap is predator diets; there is very little out there that we can use in the models. We can simulate based on guesses but good empirical diet data is just not available. **Dix** – can you determine sustainability without understanding all the ecosystem roles? **Chagaris** – it is difficult if you want to include the impact on predators, but not impossible if you're willing to make reasonable assumptions.

Public Comment

Ault suggests the obvious result of this discussion is that we need to see more cooperation between industry and science. We are on the verge of something significant. Models are models, they require data to drive these things. Within the use of RPs, I have a student merging RPs into economic throughput of the economic value of ex-vessel and industry value. How do you integrate them? That is the key moving forward.

Adjourn 5:13

Wednesday, February 13 (9:00 am – 5:00 pm)

Jones recapped and evaluated the objectives provided yesterday to develop a hierarchy of key objectives. We came up with three 'fundamental' objectives:

- Balancing the needs of the fishery and ecosystem for long-term sustainability.
- All user groups accept shared responsibility for maintaining and improving ecosystem health, population abundance, and biodiversity.
- All partners and general public have confidence in the sustainability of the fishery and the industry, and in management.

The remaining objectives provided yesterday were 'means' objectives, those that provide a path for how to achieve the fundamental, overall objective. Those included:

- Adequate SSB to ensure high recruitment.
- Minimize negative effects on predators and habitat.
- Minimize bycatch.
- Maintain sustainable commercial fishery.
- Use stock assessment data to ensure maintenance of sustainable stocks.
- Allow management flexibility.
- Take environmental factors into consideration.
- Maintain/restore historic range, age structure and productivity.
- Improve monitoring and assessment procedures.
- Have management regime in place sufficient to achieve other objectives.

Jones described the plan for today. We will start by discussing approaches to define RPs for menhaden. He noted that there are two forms of RPs for consideration. First there are theory-based RPs which are generally model generated. Second, there are empirical RPs which are based on the observation of states that one considers acceptable, or desirable with the RPs reflecting where you want to be (target) and what you want to avoid exceeding (limit). Once we have decided on a type of RP, we need to determine appropriate RP metrics and values. The Butterworth and Rademeyer

approach provides an example of a methodology to determine a good RP. We also need to understand the critical uncertainties are associated with the RPs for consideration, and to explore what data are available to inform the development and implementation of RPs. Then we need to look at the management implications of potential RPs – how will they change management in the near and long-term. Finally, we will discuss where we go next.

Approach for Defining RPs

Jones reminded the group that yesterday when **Mareska** spoke, the conclusion was that model-based RPs (MSY, etc.) were problematic for menhaden. A more empirically-based RP (something index based, observation based) appears to be better for this fishery. **Leaf** responded that he agrees but doesn't believe we can close the door on the model-based RPs. The F values we get for SPR currently are not going to be defensible in next assessment. **Mareska** agreed, noting that the SEDAR 63 reviewers argued for empirical followed by modeling later. **Leaf** noted that if we do chose some sort of index-based RP, the MAC meets often enough that it can be a very useful and pragmatic approach. When **Chagaris'** models are more fully developed, there might be model-based RPs that we could move toward. **Chagaris** noted that if we want to move to model-based RPs, this might require a redesign of fishery-independent sampling surveys, because these weren't intended to track menhaden. This is the problem with a lot of these models for a number of species in the Southeast, not just menhaden. What is going to be the investment in survey design that will be the most robust for monitoring the population and what else can we explore in the stock assessment to actually see other parameters estimated?

Jones noted that the uniqueness of menhaden is less related to stock/recruitment and more related to the life history. With the gear selectivity, the fish becomes mature before it's exploited by the fishery. This is not theoretical, it's pretty much fact. **Chagaris** – we should be able to explore these with only a couple of model runs. The SPRs could be explored further, the ones often adopted are more related to sportfish and may not be appropriate for prey species. **Dix**, for clarification, the fishery doesn't only fish on age-2s, there are others harvested and there is some error associated with the ageing? **Leaf** agreed, but noted that , they are primarily fishing on age-2s.

Considering the short-term needs to monitor the Gulf population, **Himchak** suggested that an index-based approach would provide nearly real-time evaluation of the population. In contrast, with an F-based benchmark, you need to wait for the assessment beyond the terminal year to estimate F, and then determine if you need an update assessment or just an adjustment to fishing. An index-based approach could provide a quicker turnaround for making adjustments. **Hansen** – to operationalize the RPs on a more annual basis should also have some biological meaning that incorporates issues with the biology, not just the fishery. The indices used could be computed on a regular basis but there could be some lag, depending on the time frame to process the data that would be required for application of the RP. **Leaf** did follow-up with Hansen that some of the RPs used world-wide are based in the age composition data so ageing error was mentioned because there might be a little error to consider when using these data. **Jones** – perhaps my distinction between model vs empirical is not actually a clean dichotomy. Even though you have two types, they are all based on the biology of the animal. **Hansen** concurred with **Leaf** regarding the update and the idea that the indices could become the annual estimator of success at meeting objectives. **Himchak** noted that on the Atlantic, the SSC sets a three-year plan and in the second year, do a brief update to truth the trajectory of the projection for most of the species they manage, not just menhaden.

Moncrief stated that looking at empirical approaches, he can see any number of indices that would work. As far as model-based RPs go are there candidate RPs that we could use NOW such as MSY, etc., that we would be able to look at? **Leaf** – we had a couple candidate options available during the assessment. We had one strawman that we agreed to go with but concluded that the F=M rule was probably not a good path to pursue. **Jones** summarized that maybe we have a candidate we could start to explore now and begin to move forward and then utilize something else when we have more models to include for the next assessment. **Hansen** agrees that something needs to come out of this group for management but begin to set target dates for more model-based RPs in the future.

Leaf conveyed that some fisheries use acoustic and/or aerial surveys as indices. **Mambretti** wondered if we could use preseason flights to characterize the schools and relative size of schools as a potential independent IOA. **Leaf** – would something like that be a reasonable sampling platform? **Mambretti** noted that coupled with that is the offshore trawl samples in Texas nearshore waters. Seems like these could be incorporated into the process as a way to ground-truth what the fishery is harvesting. The technology available today seems to have lots of potential to provide more relevant information for comparison to the dependent data. **Kuttel** does not object to the idea of an aerial survey but noted that there is a significant amount of subjectivity between what the pilot sees versus what's on the ground. Acoustic surveys seem to have been the most reliable means of determining what's below the surface.

Himchak noted that at one time, **Leaf** had presented proposal on acoustic survey of biomass. How long would a survey like that take early in the season in the fishable area of the Gulf? **Leaf** indicated that acoustic surveys can cover a lot of ground. However he noted that using acoustic surveys or spotter plane data would entail the formulation of a new index, which means we would need to establish a long-term dataset to be able to use them as an index. At this time, no one is aware of any hydro-acoustic surveys going on that would provide historical menhaden data. **Chagaris** asked about the SEAMAP trawl survey – maybe those vessels could be utilized. **Landry** noted that Omega keeps flight logs on East Coast on Sunday to identify where boats should begin to fish on Monday and they provide this data to NMFS. There was also an aerial survey north of NY was done in 2010 because independent sampling wasn't picking up those fish. All the survey data had to be ground-truthed for ageing those fish however. This type index loses some fish in the total biomass that are not observed by spotters. **Leaf** – the concern with using the gillnets as an adult IOA is that the sampling doesn't represent the population dynamics of off-shore population where the fishery operates and beyond. We really do not know the density offshore. The assumption is that the inshore isn't perfectly representative but it's appears generally consistent. The combination isn't perfect but together the two indices actually do a pretty good job tracking abundance. SEDAR 63 reviewers were relatively comfortable because they were reliable over time and quite frankly, the only game in town. **Chagaris** notes that there are other parameters you could generate from the assessment process. **Leaf** – so now we're almost proposing a hybrid modeling/survey index as a *post hoc* treatment of the survey data beyond the standardization. **Jones** – but the data are standardized already. There is a benchmark assessment which the reviewers indicated that they have some confidence in the independent data which provided the indices to inform the model. They aren't perfect but they aren't deeply flawed either.

Dix wondered if we aren't monitoring menhaden offshore at all. Is there a significant portion of the menhaden population that lives offshore? **VanderKooy** noted that there is independent sampling

offshore by the SEAMAP survey. The TPWD trawls were also part of the SEAMAP sampling for a while. During SEDAR32, Brian Langseth ran an in-depth analysis of the menhaden catch in the deep-water trawls and found there wasn't a lot of data to use. The survey wasn't designed to sample midwater or surface waters where menhaden are found. The states' independent sampling is still the best and only data that really has reliable menhaden data for use in the assessment.

Himchak mentioned that in the Atlantic Menhaden 2015 benchmark, they explored a lot of data (44 datasets) but found that they actually had to form a fishery-independent group to do this because none of the surveys were explicitly designed for menhaden. So we have standardized our independent datasets but are there additional processes we could put the current IOA through now? **Chagaris** said that with sampling in the bays only, there are processes that can be used for spatial filling. If fish move in or out of the system where the sampling occurs, movement could be interpreted as a decline rather than just a movement. There are other levels beyond the more traditional approaches like GAM or GLM. **Jones** agreed that the Atlantic's fishery-independent survey group has a very difficult time dealing with the large number of possible datasets. What is being described is the use of modern statistical methods to incorporate covariates (random effects) into the interpretation of the indices to separate abundance signals from other sources of variability (noise). This is probably worth doing just to improve the indices for use in future assessments.

Landry would like to have **VanderKooy** add an item to the MAC meeting agenda (March or October) to focus on RPs suitable for the fishery and discuss what surveys would be needed to apply to a model-based RPs in the future.

Moncrief – I think we've pretty much agreed here that we are going with indices and an empirical approach. Let's look at the data we have and determine the pros and cons of each for informing the RPs. **Leaf** indicated that the assessment can provide a lot of this information. The same datasets we used developing the original IOA for the assessment will provide the arguments for whether to use them for the RPs. **Hansen** – are the datasets used in the assessment actually appropriate for making projections to monitor the RPs. **Jones**, this leads us to the next idea of perhaps using MSE to explore this.

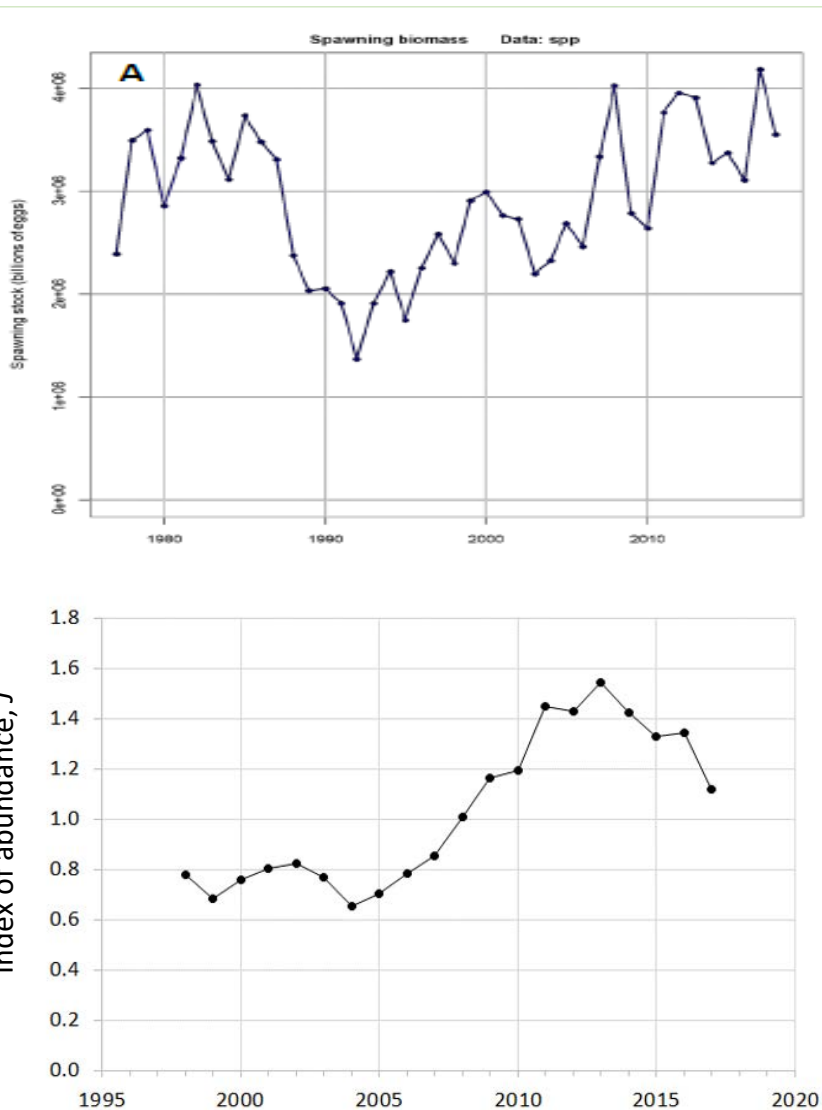
break

Following break, the group watched the Butterworth video on management procedures using MSE to determine a robust measure. **Jones** reviewed the Candidate Management Rule from Butterworth and Rademeyer's presentation. When Butterworth talks about a management procedure, he's basically talking about a combination of a rule that specifies what you do in setting something like a TAC and how you collect the information for how you apply the rule. In his candidate example provided earlier, the data are the combined seine and gillnet indices (J_y). The limit RP is triggered when the index drops below 0.8, with the action taken being a directly proportional reduction in the TAC relative to recent fishing levels. Again, this is just a candidate as an example of a Harvest Control Rule and to illustrate how an MSE would be used.

Dix – when we were talking about RPs before there seemed to be agreement to not use model-based approach to determine RPs yet when we are talking about evaluating management techniques, we are arguing FOR a model-based approach. **Jones** admits that this had the potential for confusion. The

distinction here is that the model (MSE) is being used to examine a RP that is NOT model-based. It is the testing method, not the Reference Point itself that uses a model. Leaf – the idea is that these index based RPs don't have any theoretical basis, which would imply use of a model to define, as opposed to evaluate, them. We are letting the “experiment” of the fishery determine what would be a reasonable level of abundance. Model-based RPs make assumptions that we understand the mechanisms driving dynamics of the stocks. **Himchak**, don't we still need to generate all the same information we derive from the BAM model for the stock assessment? **Jones** – this rule doesn't require it. All we have to do is continue to collect the gillnet and seine index data to generate the annual index and apply it on a three-year running average to determine if you need to apply the catch limit (TAC reduction). It's likely you will still with to do the assessment as before, but practically speaking you could simply use this method to manage. The MSE analysis explores the application of the RP and harvest control rule by forecasting plausible futures and seeing how often the rule results in the outcome we are seeking (i.e., TAC reductions when needed, but not when unnecessary).

Hansen, the primary issue moving forward with the proposed IOA is that it doesn't incorporate an estimate of the actual SSB. We could use the assessment model to estimate SSB_0 (unfished biomass) to determine how the index compares to what would be expected in an unfished environment, and select a RP that works with some percentage of that value. **Leaf** – you could also use the time series of SSB which we have and compare it to the IOA to refine what our trigger value of J should be. But the limit or RP will be based on J . **Hansen**, if you want a target of $75\%SSB_0$, and then look at J_y for a year that was at this level and that becomes the trigger. **Jones** – it's not too different from what Butterworth and Rademeyer actually suggested. On the graph of SSB, that's pretty much where we are with the 1992 year. The index doesn't even include the lowest year, it starts at 1997. If we generate it based on a longer time series, **Jones** expects that the result would be a less conservative RP, compared to the one examined by Butterworth and Rademeyer. **Leaf**, the reason why we start the index at 1997 is because that's when the gillnet data begins. **Hansen** – you really need to know what the SSB_0 (biomass of unfished stock) is to inform where the level should be. How does the current rule relate to SSB_0 . **Mareska** would like to see the run on the SSB_0 but we do not want to abandon the index of abundance because recruitment, these days, is sometimes more environmentally driven than SSB. **Hansen** – it seems to me that the HCR seems to be where you should keep the catch at... so the Butterworth and Rademeyer approach kicks in once the fish have already been removed. We need to have the rule keep you in the 'good zone' not force you back into the good zone after the fact. **Jones** – that comes back to objectives, we need to have good RPs so we can have targets and limits which keep us in those 'good zones' and this is the intention of the example. Using the MSE, you construct a candidate rule and run simulations to see how well it actually works and what kind of risk is associated with that rule. **Leaf** – if you look at the time series of SSB and the composite index, the lowest SSBs generated in the assessment are in the mid-1990s and the CMR is capturing that. This J series might be missing the very low part of the fishery but the series leading up to 1997 is smoothed so it includes the tail end of the low period. The index is a running average so additional years might flatten it a little but are not likely change it much overall.



Mareska believes that this example evaluates a limit but not a target. We might need to go back further in the time series so we do get closer to that unfished biomass (SSB_0). **Ault** – the only way this index can work is if there is a proportionality between the stock size and index. This is essentially also true of the assessment model (BAM). The sampling survey must reflect the underlying stock status that provides the measured index. They need to be correlated. **Jones** – agree that if you are skeptical of the fishery independent data and thus the indices, this would be a problem. However he noted that the reviewers for both benchmark assessments accepted the indices as informative sources for the estimation of stock abundance. **Leaf** – while not in the report, Butterworth also agreed that maybe the other states time series (other surveys) could be incorporated as well but the two indices we already have are well correlated, and are the ones used in the assessment model. The CIE reviewers were satisfied with the measures used in the model and we spent a lot of time looking at the correlation between all the potential datasets to make sure we addressed this ahead of time.

Jones – this leads to a big task for this group: to decide which candidate RPs to explore, which datasets to include, and then develop and run MSE simulations to see which RP performs best at meeting management objectives. This is not a trivial task. As we think about multiple candidates, some

participants will be uneasy about the degree to which we can quantify the importance of menhaden in the ecosystem. We obviously believe they play an important role, but we are not able to quantify this yet based on the evidence provided during yesterday's discussions.

Discussion of Biological Uncertainties Related to Determining Reference Points

So with that in mind, how do we deal with the uncertainty? The industry doesn't want to negatively affect the population to where they can't fish but we need to protect the other ecosystem services that menhaden provide. Most everyone would agree that we don't have good answers to yet. So where does that leave us? **Dix** – if there is uncertainty, we should err on the side of conservation. **Jones** – that's probably widely accepted. **Hansen** – when you look at the time series of biomass, at that low point we can't show any negative impacts but we can assume that high levels of biomass are positive for predators. We should shoot for a higher limit to be sure you stay on that positive end and don't get as low as the lowest point. **Leaf** – you're right but we also need to be sure that our targets and limits are not too close together, because that would lead to frequent "tripping" of the HCR, which is undesirable from a management perspective. Given the uncertainty in the estimates of abundance based on the indices, it's likely this would lead to a lot of false positives and negatives. The limit should truly be a limit. **Dix** – why is this a problem? **Leaf** - the fishery should have some reasonable band of limits to make sure that they don't end up in restricted status and impose a lot of unnecessary management. The states don't have any laws on allocations for harvest of menhaden (except Texas). **Jones** – its administratively difficult for an agency to manage based on a continual response need, especially when the evidence of the need for a response is quite uncertain. There is likely a wide range of SSBs that would lie within the target range for the fishery to operate. **Dix** – are there other fisheries where the impact on the fishery is the driving factor in setting up management or is this unique to menhaden? **Jones** – in my experience there are a many fisheries where an important management criteria is associated with the stability of the fishery over the long term.

Landry – in the absence of hard data, there should always be caution. Are there times when we have observed food-limited predator species or where the size or abundance of predator fish has declined? **Ault** – In theory, predators behave exactly like the industry... if you waste a lot of time searching for food, your benefits versus cost go down just like the predator's growth and reproduction go down. Food needs to be profitable and available – the fish need to gain energetic returns from the fish they pursue and consume. **Landry** – do we know if are there any species that are food limited because of menhaden? **Jones** – would it be more accurate to say there is "no evidence of an effect" or that there is "evidence of no effect" of a reduction in menhaden abundance due to fishing? That is the context in which this must be asked. **Chagaris** – this is related to functional response. What is the strength of the functional response as food supply decreases? There could be some modeling of how predators respond to different levels of menhaden. All ecosystem models assume that these predators are being affected. We should be able to run a single species model parallel to the ecosystem model and see what the predator responses align with. With an index-based approach it will be more difficult to compare with an ecosystem model. Index based approaches may not be usable in ecosystem based models because the latter rely on biomass estimates. **Hansen's** suggestion for some sort of hybrid approach might be a useful way to do this and still utilize ecosystem-based approaches in the future. **Chagaris** also pointed out that Jim Uphoff showed that when Atlantic menhaden abundance was low, striped bass size was low. Even in the presence of good predator data, increased competition among predators could lead to lower condition despite moderate levels of prey. Teasing density dependence out is a difficult task. **Jones** – we do have the means to connect the dots to compare indices to

biomass: the relationship between the indices and the actual biomass estimates is implicit in the assessment model. **Chagaris** is concerned about the currencies between the models which is always the issue but it's a speed bump. **Leaf** reported on his work with his student Meg; she is finding that most predators in the GOM balance their diets similar to our retirement packages (diverse portfolio). When a particular prey type is abundant, predators target them. When they are lower in abundance, predators will utilize other prey. When you look at the literature and the predators we have in the Gulf, many are actually more generalist than specialists, as reflected in what **Chagaris**, Sagarese, and others are modeling. The oil yield and condition of prey is controlled by bottom up drivers and at some times, menhaden are not as highly profitable prey. Their caloric content is not always high.

Jones noted that we are at a point now where we are going to have to address the value of menhaden as prey in any RP and it needs to be defensible. The group will need to determine how to evaluate the effect on the ecosystem. At times of lower abundance and high landings, the predators were also low so their demand was low and we may not have been able to see the impact that would have occurred had predators been more abundant. **Himchak** – Olaf Jensen has made presentations on the portfolio effect of predator productivity and harvesting forage fish. Jensen looked at a number of clupeid prey, which could be helpful for this work. **Leaf** noted that **Chagaris'** model actually does this for us already. The Jensen material is useful from a high altitude look but we have much more specific data for our analysis.

Mambretti revisited the buffer zone between a target and threshold so that a TAC was reasonable and not requiring continuous implementation of the HCR. **Hansen** – setting a limit and reaching or hitting the limit does not generally mean shutting down fishing. The response is to ratchet back and reduce the impact by slowing down the fishery. **Mambretti** - Texas does operate that way on its TAC and with real-time monitoring, they can tell the industry to slow down as they approach. **Hansen** – this ultimately goes back to risk and how much the managers are willing to take. When you go too far past the limit, it's harder to bring the biomass back quickly as fishing is reduced.

Public Comment

Venker – The CCA is very interested in the 'reduce bycatch' objective and that has not been addressed yet today. Instead of one of the objectives being minimize bycatch, perhaps the bullet should have said 'quantify bycatch' so it can be determined if there is a need to reduce or minimize bycatch. If that is a goal, that is an uncertainty that must be included. **Jones** agreed that we really haven't talked about bycatch yet.

Himchak reported that on the Atlantic, there are three observer programs which include ESA (Endangered Species Act), MMPA (Marine Mammal Protection Act), and the SBRM (Standard By-Catch Reporting Methodology). Under SBRM, NOAA is required observe a certain number of trips and allocate those trips to those fisheries that have the highest bycatch. They observed 29 trips between 2007 and 2012 and have not continued observing because they didn't witness much bycatch. In the Gulf, there are very few bycatch observer programs and limited funding. They are dominated by ESA and MMPA observers and focus on longline and other fisheries. We don't have observers for the menhaden fishery because they tend to focus on high bycatch fisheries. There is a lack of standardization in the approaches conducted historically so there are issues with comparisons. The industry has taken a number of actions to reduce bycatch intentionally with a number of technologic advances. **Dix** had talked to LSU researcher whose biggest regret was he was unable to complete his

menhaden bycatch research from the 1980s and 1990s. When they declare it a 'clean fishery', who is they? **Landry** – NOAA Fisheries has declared bycatch in the menhaden fishery as insignificant. **Leaf** – with the data limitations, it would be unreasonable to use bycatch as the basis for an RP. **Hawk** confirmed that under MSC, bycatch is key in going through the certification process, so this issue is likely to be addressed separately from the RP component of MSC certification. **Kuttel** – the technology has been improved over time and will continue to be improved. It will also be considered in the MSC evaluation.

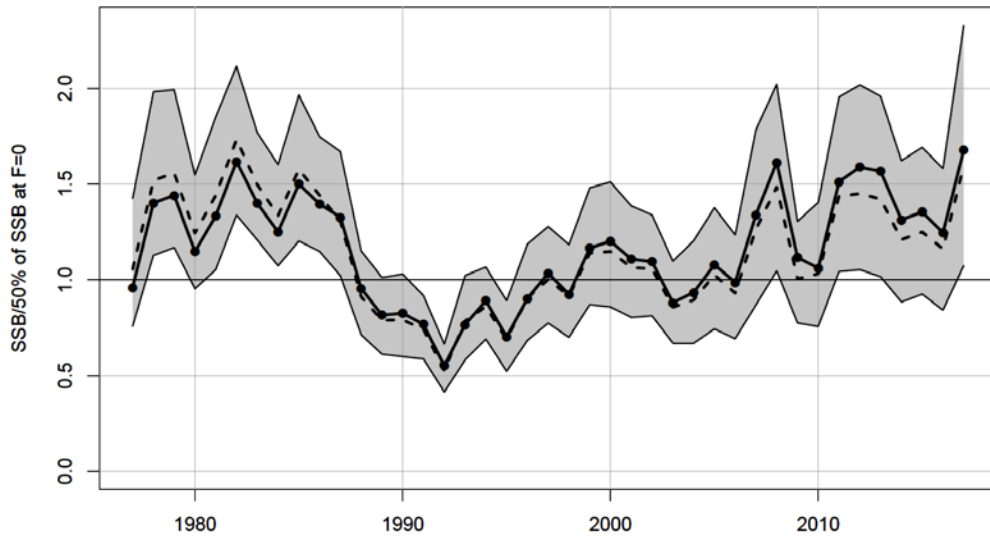
Hansen – I agree that old data are bad and reliance on infrequent observers is unreliable. Is there going to be requirement under MSC for current monitoring of bycatch under the current best practices?

Hawk – we won't know until the public comment comes out but potentially. As technology is improved, the assumption is that the fishery under certification will adopt that technology as well.

Hansen - is the limit on bycatch on the various fleets monitored? Have they ever calculated the actual percentage of bycatch onboard? **Mambretti** – wardens will board vessels and examine the catch in the hold to make bycatch determinations. **Landry** – in Mississippi, the agency does board the vessels on a random but routine basis.

lunch

Jones reminded everyone where we left off on uncertainty. There is uncertainty in the data available as well as in the information you have for evaluation. **Moncrieff** – we always have to take into account that these fishery-independent surveys are funded annually but that funding can vary and surveys might need to be constrained due to other parameters including disasters or higher priority activities. Those potential changes could be some of the uncertainty that needs to be considered... the ability to continue deriving the indices. **Hansen** – on the gillnet index, there is a lot of noise in the mid-2000s... is that a sampling issue or something else? **Leaf** – something in the model is not tracking the index well at that time which is why the larger residuals are observed from the assessment model. **Jones** – this happens when two datasets contradict each other. **Leaf** – that may be true about model specification but the MSE analysis doesn't include anything from the BAM output, these are the indices standing alone. Uncertainty is reflected in the lognormal residual distribution that drives the deviation between the observed index value and the true abundance in the MSE model; this allows the MSE to examine how accuracy and precision of the index affects performance of the RP/HCR. **Hansen** – it would be good exercise to conduct a dedicated survey for menhaden to see how well the index tracks. If we move forward using the indices, it would be a ground-truthing effort for the historic data and if it doesn't, it would support having a targeted survey for menhaden. **Leaf** – it's not my sense that any of the states have the ability to add another survey just for menhaden. The other states have additional sampling data which corroborates these indices but weren't included in the combined index J. **Hansen** – Looking at figure 7.45 from SEDAR63... SSB tracks pretty well with the index since the index drives the model. Couldn't we correlate the Butterworth and Rademeyer index to the BAM outputs. Perhaps an $SSB_{50\%}$ seems to track fairly well for a potential candidate as a strawman limit – it seems to correlate well. **Leaf** – this is great, it provides an alternate candidate to the value of 0.8 that we can explore in the next realm of simulation. **Hansen** - But how does that relate to the unfished stock? Is there a way to equate a SSB_0 to these levels? **Leaf** – The SSB trajectory data seems to be a reasonable approach to developing other candidate RPs. **Chagaris**, couldn't you use the scalar that you used in the model to deal with the index? **Leaf** – yes, this scales it up to SSB and could be applied although there is still uncertainty around that scalar but yes.



SEDAR63 - Figure 7.45 Estimates of the population fecundity (*SSB*) relative to *SSB*_{50% at F=0} from the base BAM model (connected points) and the median from the MCB runs (dashed line). Shaded area represents the 90% confidence interval of the bootstrap runs.

Jones – is there any other ways of dealing with the uncertainty in the data? We talked about alternative sampling (acoustics, etc) that could potentially be used in the future. This leaves us at a good place to perhaps run a few of the options through the MSE process outlined by Butterworth and Rademeyer in another workshop/working group format in the future.

Discussion of Management Implications of Reference Points

Jones – from an agency point of view, a management regime which requires a lot of maintenance and intervention without compelling information to justify it is potentially problematic when there doesn't appear to be a strong need to change management. **Moncrieff** – in the MSE example at 0.8, there were six times that the index fell below the example 0.8. In the modern era of the fishery, was the fishery really in trouble at that 0.8 value? If you look at everything else, would applying a HCR for those years have actually been necessary? **Leaf** – if the target was not set at the correct level, it should be changed. The limit should allow for the most to be harvested without hurting the ecosystem. The management strategy should be that you can allow for the surplus production in the population to be harvested. You are pushing as much as you can out of the stock. **Kuttel** – the HCR in the example suggested they should have only harvested 300,000 mt but the following years the index was fine indicating that a 0.8 cutoff doesn't indicate a true problem... and it would lead to potential workload for managers. **Hansen** – if we are doing in-season monitoring, and if we're setting our target near the current harvest levels, the fishery could adjust as needed near the end of the season. The RPs would be based on the catch-levels and make adjustments after the assessment phase. **Leaf** – you would want to allow for larger harvest when the stock is very high. The RPs is not currently tied to the harvest it tied to the index. **Jones** – there is about a year lag with the example RP and is combined with the prior two years. That raises an interesting question. What happens within the year regarding catches, does high catching mean too much fishing is going on or is the stock just high? **Kuttel** – because it's a three-year running average, we will get a hint that something is changing, it's not just going to spring up on you.

Hansen – part of this should evaluate the use of a two-year vs three-year average as appropriate. Short-lived species may not be able to tolerate a three-year lag. **Leaf** – agreed, your index could incorporate the most recent year so you could weigh the most recent... and adjust each earlier year less. If you are looking at the J index in 2000, you would incorporate back to 1998 but apply more importance to the most recent year or last two years. There is flexibility here. **Jones** – for this species, four years would be nearly a full generation time so averaging over a longer time period might not be appropriate. A shorter window would probably be preferred. **Landry** – does the variation around the SSB estimates from Butterworth and Rademeyer’s presentation indicate little effect in the annual variation? It seems more like a series of regimes with low periods and high periods, there is a lot of bouncing. Could you have some sense of confidence that even at higher fishing levels, we aren’t crashing the population? Harvest bouncing is more tied to effort and fishing days, not the population availability. **Hansen** – the landings are fairly consistent in the last 20 years between 400-600k mt so that would be a good place to keep the landings since it’s the current sweet spot for the industry anyway. **Jones** – that is the two dashed lines in the Butterworth and Rademeyer example for the NCR. Is this the reality of the industry right now? If there’s no impediment to expansion, would the industry potentially do so? **Kuttel** – obviously any company or business would have plans to expand when they can. There’s no way to tell what the future holds but if there is no biological meaning to restrict the fishery, they might want to be able to take advantage if it was scientifically safe. It sounds like the states do not want to cap this arbitrarily either. **VanderKooy** – The dashed lines don’t restrain the catch, they’re not targets and limits correct? **Leaf** – yes, but they DO restrain the model and how the performance of the HCR is measured. That is why the robustness scenario was run because there was no limit.

Mareska – if we are evaluating this on an annual basis, how much does environmental conditions play into the index. For example, in drought years, the gillnets may not sample as well if the population is not in the sampling area giving a false negative. **Leaf** – general hydrology is included in the standard index so it already helps smooth the data. **Moncrieff** agrees that conditions when the survey is conducted could result in false negatives when you consider the variability so averaging multiple years is useful in this regard. **Chagaris** isn’t sure if the index standardization is all that reliable. This is the biggest concern with the index since it’s not actually designed for sampling menhaden. If we don’t have confidence that the variability of the indices reflects variability in abundance, is there anything that could be done to adjust to truth the index? If other surveys corroborated the index, we could at least have more confidence. **Leaf** – in the current management scenarios, there are not going to be other surveys added for menhaden but the suite that we do have available might be better correlated to other existing datasets. Maybe there is something biostatistical we could add to the independent or dependent data that would tell you something about the stock although it wouldn’t be ground-truthed? We do have condition factors, length comps, etc. in hand and incorporated into the stock assessment in another way already. **Chagaris**, not sure there is anything better just keep a level of ‘skepticism’ in the data. There are likely other datasets which would show similar trends and could support the index. Maybe one out at the margin of the population range would be helpful rather than just the center of the population.

Hansen – these conversations are potentially helpful for elevating these data issues in funding cycles. Menhaden should be elevated in the SEAMAP and other funding sources so we have something that is a better index in the future. This is one of the largest fisheries in the Gulf but we don’t have a

dedicated survey. If PEW could cut a check to cover it, they would. **Jones** – one of the benefits of pursuing an MSE process, is that it can justify (or not) the need for better assessment information. If the index is predicated on the quality of the existing data, some effort should be directed to better sample it. If it's not an at-risk fishery and the uncertainty isn't that critical, maybe those resources should be redirected to other issues, not menhaden. An exercise like this can tell you just how critical the uncertainty is.

Hansen – so moving forward, how is an HCR implemented, how does this become operational? Is the Commission and MAC going to move this to the states? The states are the ones who actually manage the fishery, not the Commission. **Landry** – some infrastructure would need to be put in place like with any other fishery where the MAC monitors and established HCR rules. The states would have to make decisions to implement those and work with NOAA to monitor in real-time and enforce it. Most of the structure is probably in place to do that. If we come up with something for RPs, industry would push it in the states they operate in to establish it in management. **Hansen** – if there is a reduction put into place, are they across the Gulf or by state and does it require something like an MOU in order to deal with allocation issues? **Chagaris** agreed there will need to be allocation decisions made. **Himchak** - with completion of benchmark and FMP revised through 2015, would you rewrite the FMP? The MAC already has management recommendations to spell out how it should be laid out. **VanderKooy** – the Commission has no role in management. The MAC is an advisory committee to the Commission, not to the states. The states actually make decisions to implement anything. If managers on MAC agree and go to their states and present, it may still be difficult to do across all states. Another possibility is that industry could do this on a voluntary basis rather than through regulation by the states. This is how most of the current regulations came to be; they were already in place and done through industry practice first and then states adopted them as regulations (fishing areas, season, etc.). This may not help with MSC in the short-term however. **Himchak** – so unless there is buy-in from the states and formalization of an HCR process, we're not progressing any further than where we were at SEDAR32A. Have we even followed advice from previous FMP? **VanderKooy** – exactly. The fact that the industry is at the table and requesting this doesn't imply that the states would join in. Ultimately, the states need to make the decision and it might require a legislative action, not an agency action. **Moncrieff** – **VanderKooy** is correct, in Mississippi, we have our own regulatory body but it's not on the agency. Each state is different. **Mareska** – what stops the industry from participating on their own? The CDFRs are not required, they provide them voluntarily.

Kuttel - What would MSC be looking for from industry? **Hawk** - In some cases there probably are fisheries that regulate themselves. She does not know menhaden specifically. **Kuttel** - if any industry could control itself, the menhaden industry could with current status quo. **VanderKooy** – The fact that we are having this meeting with all the stakeholders involved, if you come up with some management that everyone was willing to sign onto, the selling point at the state level would be much easier. The state agencies and legislatures would likely embrace if industry and other ENGOs were onboard. **Jones** – considering the diverse group of interests at this table that want this pursued, would the Commission be able to produce something? **VanderKooy** - If the MAC puts something formal together, they could look for endorsement from the stakeholders involved. **Himchak** – we have two tasks, first, refine the RPs and HCR through the MSE process and second, the MAC needs to formalize something as a recommendation to the state Commissioners and the state agencies. **Jones** – is there a need for more support for this process in order to move on? **Himchak** - The technical analysis is necessary before bringing it to MAC. There are too many uncertainty discussions that must be addressed first.

Hansen recommended to **VanderKooy** that MAC get this process started to understand how each states management scenario works and what the process is to get this accomplished. **Jones** – I think most everyone sees the value in pursuing this. Is the sense that the ENGOs would be supportive of this as a proactive approach? **Hansen** – most likely because we are in what appears to be a sustainable level of fishing at this time so we would like to see RPs that have meaning and an HCR associated with it. I think all would be happy if there was accountability and enforceability to do what the intention of the RPs are. Obviously we think the more fish left in water, the better... for the resources and even for the industry. **Jones** - RPs are designed to assure sustainability of fisheries but when the typically opposed parties are aligned in support of something, the influence can be very strong on decision makers. **Himchak** - recommendations from SEDAR32A have not really been followed through on. We need to stop kicking the can on RPs. Industry welcomes this effort.

Discussion of Future Steps

Jones summarized the steps he heard during the preceding discussion. First, the states need to discuss willingness/ability to collectively implement management procedures if developed. Second, there is a need to determine whether MSC considers proposals where industry self-regulates. Third, determine if the MAC could develop recommendations and seek endorsement from other parties. **Hansen** – so we are leaving here with an MSE workshop proposed. Is that going to happen at a MAC meeting or is that a standalone workshop like this one? **VanderKooy** is awaiting some direction from this group as far as how to have the MSE exploration. How do we solicit the potential candidates, what level of risk is everyone willing to accept? It sounds like a data driven workshop needs to happen, basically like an assessment workshop. At the MAC meeting in March, we'll have the members outline the legislative, statutory, etc. process for each state to pursue this. The MSE isn't a MAC function so it's something that would need to be organized and scheduled for later this spring, maybe April or May. **Landry** – we had targets and thresholds before MSC was pursued. We still didn't have RPs from the previous benchmark, it was completed by the MAC after the assessment. Isn't this what MAC would do anyway regardless of MSC? **VanderKooy** – this process we've started here is exactly the same thing we did after the first benchmark assessment. We held a number of conference calls to explore potential RPs and then the MAC approved those for inclusion in the FMP later. We're not working on an FMP now so once we agree to RPs, the MAC will approve and move them forward to the Commission and the states. We operated before under the assumption that the RPs we had would guide fishing effort and they were checked against the landings gathered by NOAA. There were no HCRs although there were requirements to go back into a population assessment if the RPs were breached. It was never adopted at the state level, we just monitored it through the MAC informally. **Moncrieff** – the obvious next step is moving forward with the MSE and begin to determine what we intend to propose. **Hansen** – the current RPs have no mechanisms in place to respond so anything we do here that provides actual triggers and responses is important. How are we going to proceed and who will do the MSE analysis? Will the Commission's stock assessment panel do this or will we need someone from outside? Is there funding to keep this going? **VanderKooy** – the MAC members as well as the workshop participants will contribute to the discussion and we will likely have to contract someone to run the models. These things will need to be figured out. This is not NOAA's role so we need to do this. However, in the long-term, we will need to find a funding source if this will be updated annually so we can ground-truth where we are over time. If there is no support to maintain this work past the workshops, MSC probably won't be happy. **Hansen** noted that inclusion of the NGOs was important but he encouraged a variety of stakeholders to be included in the future. **VanderKooy** – if you look at the amount of food on the

tables in the back, we expected a lot more audience participation based on the responses prior to the meeting. The actual turnout outside the table was low.

Workshop Accomplishments

Overall the group spent two days working on five basic objectives for the workshop:

- to discuss the purpose(s) for reference points,
- to identify candidate objectives for the fishery,
 - The group was fairly consistent that the objective for the fishery was to “*Balance the needs of fishery and needs of ecosystem to maintain long-term sustainability*”. There was consensus by all stakeholders that a vibrant and robust fish stock was critical.
- to review the current status of Gulf Menhaden and the fishery,
 - The group understood that the stock and fishery status is dependent on the reference points used in the fishery and that these had not been satisfactorily determined. However, the independent expert reviewers of SEDAR63 were in agreement that, even absent this information, the fishery was not overfished nor was overfishing occurring. The group was united in their belief that this was the case but agreed that the ecosystem implications of different harvest levels remained a challenge.
- to assess candidate reference points, and
 - The group all agreed that at this time, empirical index-based reference points were practical but that hybrid reference points (model and survey index) could be used *post hoc* as a treatment of the survey data. All agreed that the original M=F reference points provided as a potential candidate in the stock assessment were not appropriate.
 - The group agreed to follow this workshop with additional workshops to explore potential index-based reference points. No specific options were provided as candidates beyond the one included in the Butterworth and Rademeyer MSE example, which was seen as a useful starting point. The group would hold a series of conference call/webinars and provide the MSE analysts a list of candidates moving forward.
- to discuss management implications.
 - The group agreed to explore the issues by state regarding potential implementation of management reference points and harvest control rules. The first discussion of the management process would occur at the March 19, 2019 Menhaden Advisory Meeting in New Orleans.

Wrap-Up

VanderKooy will put together a summary of the discussions and provide a written report to all and begin to organize an MSE workshop. **VanderKooy** will set up some conference calls to help prepare for the next workshop. We need to have a list of candidates and allow an analyst or team to have a chance to review the data required for the various RPs and sort through all the background information so the participants in the next workshop have results to look at. Not sure how long this will take or how we will fund it but we will begin the process immediately.

Jones thanked everyone for their cooperation.

Adjourn

The workshop concluded at 3:30pm

Appendix A

Participant	Proposed Objective(s) for the fishery are to:
Hanson	Manage to balance needs between fishery and ecosystem to maintain long-term sustainability.
Himchak	Maintain a level of SSB sufficient to provide adequate recruitment for long-term sustainability and have no negative impact on the environment.
Leaf	Balance the risk of harvest but understand unique characteristic of the stock.
Chagaris	Optimize harvest without negatively affecting predators, bycatch, and habitat.
Kuttel	Maintain sustainable commercial fishery so as not to degrade the ecosystem/habitat.
Moncrieff	Manage stock within optimal sustainable levels.
Mareska	Maintain sustainable stock as measured through stock assessment.
Adriance	Manage fishery for maximum sustainable harvest based on stock assessment. Provide flexibility in management.
Mambretti	Maintain long-term optimum sustainability based on sound management, monitoring, and regulations.
Martinez-Andrade	Take environmental variable into consideration.
Landry	Maintain healthy adult population to ensure optimal egg production in subsequent years.
Dix	Ensure that all user groups who live and work on and near Gulf take shared responsibility for not just maintaining its health, abundance, and biodiversity, but improving it and instill confidence in sustainability of the fishery, industry, and management.
Hansen	SECOND TIER: Maintain or restore historical age structure and geographic range, and maximize reproduction and productivity. Improve and maintain population of species monitoring and assessment as appropriate for its growth environment.
Dix	SECOND TIER: Maximize the calories and prioritize for human consumption, directly or indirectly. Everything we harvest out of the Gulf should go to the most widespread human benefit. Primary purpose of harvest should be for prioritizing consumption of food for people. Could be further down food line.



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