Atlantic States Marine Fisheries Commission

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MEMORANDUM

October 27, 2015

To: Atlantic Menhaden Management Board

From: Biological Ecological Reference Points Workgroup

RE: Ecological Reference Point Recommendations for Draft Amendment 3 Development

The Biological Ecological Reference Points Workgroup (BERP WG) has been tasked to develop ecological reference points (ERPs) that will be considered with changes to the Atlantic menhaden management program in Draft Amendment 3. In the *Ecological Reference Points for Atlantic Menhaden* report, the BERP WG presented a suite of preliminary ERP models and ecosystem monitoring approaches for feedback as part of the 2015 Benchmark Stock Assessment for Atlantic Menhaden (Appendix E, SEDAR 40 Stock Assessment Report). In August, ASMFC conducted a facilitated workshop with managers and stakeholders to develop specific ecosystem and fisheries objectives to drive further development of ERPs.

At its October meeting, the BERP WG used the outcome of this Ecosystem Management Objectives Workshop (EMOW) and the SEDAR 40 peer review recommendations to assess the ability of each ERP model or tool to address management objectives and performance measures. The BERP WG identified fundamental objectives and performance measures from the EMOW that can be addressed using ecological models and approaches. Objectives such as "Sustain Atlantic menhaden to provide for historical and cultural values" or "Achieve broad public support for management" would require additional data (e.g., socioeconomic) or identification of relationships that are outside the purview of the BERP WG.

Based on committee deliberations, the BERP WG recommends using a surplus production (Steele-Henderson) and a multispecies statistical catch-at-age model to formulate potential reference points. Table 1 summarizes the recommended models and the fundamental objectives each model can address as well as the associated performance measures. Models were selected based on: (1) the ability to address multiple management objectives; (2) the ability to predict and monitor performance measures in response to management action; (3) technical merits; and (4) adherence to the advice from the SEDAR 40 Peer Review. Additionally, a majority of the BERP WG was in favor of using ecosystem indicators (e.g., forage indices or predator prey ratios) as a monitoring tool, which would give an empirical indication on performance of some management measures and indicate when to use modeling tools to assess the system. A minority of the BERP WG suggested that the ecosystem indicators be considered to develop harvest control rules as standalone alternatives to the other modeling approaches. At the next meeting of the BERP WG, the minority members will provide examples for committee consideration, and a final recommendation will be made. Currently, the BERP WG recommends their use only in an ecological context in conjunction with the other approaches rather than as standalone indicators.

The BERP WG also discussed models that are in development outside of the committee. External models such as a coastwide Ecopath with Ecosim and another surplus production model will be explored and compared to BERP WG modeling efforts as appropriate during the BERP

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WG process. Because these efforts are not a draw on committee time, the BERP WG agreed that the findings from these models would be useful to compare to BERP WG modeling outputs to check for convergence.

The BERP WG notes that the timeline for model development and subsequent review will exceed the current tentative timeline for Draft Amendment 3. Creating ERPs from these models will take three to four years before being ready for management use. Three to four years is on the order of a new stock assessment with the added complications associated with modeling multiple species using a suite of models in order to address management objectives. The multispecies models will require six months to a year to complete development of the code. Because these are complex, brand-new models, the BERP WG and the menhaden TC will require a year or two to review and test the models, to ensure that the code is correct and the models are robust and performing well. During this time, the BERP WG and the TC will also have to gather, vet, and update all inputs for a standard single-species assessment for menhaden, as well as the same data for all the predators included in the model. During this process, the BERP WG will periodically present updates to the Board and request feedback where applicable. Once the BERP WG and TC are satisfied with the performance of the models and the final model runs are completed, the models and inputs will have to be peer-reviewed, then presented to the Board, which will require three to six months. When the Board has accepted the multispecies assessment framework, the BERP WG will conduct a Management Strategy Evaluation (MSE) to quantify the effects of different levels of fishing mortality on the objectives identified by the Board. This will allow the Board to examine the tradeoffs between different objectives and select ERPs that achieve the desired balance between all objectives. The MSE will require six months to a year, depending on the range of options the Board wants to consider.

In the interim, the BERP WG recommends that the Board continue the use of the BAM single-species biological reference points as accepted for management use from the 2015 Benchmark Stock Assessment for Atlantic menhaden. The Board may also consider an *ad hoc* ecological control rule such as those found in the Lenfest Forage Fish Report[1], E=F/Z =0.4[2], SPR = 30 or 50%[3] well as others outlined in Department of Fisheries and Oceans Canada review[4]. Although these *ad hoc* reference points are easily calculated, they are generalized rules of thumb based on meta-analyses of multiple species. The BERP WG previously reviewed the Lenfest Forage Fish Report and did not feel that the management actions recommended in that report are appropriate for Atlantic menhaden management (see Memo M15-30). The BERP WG met with the Lenfest Forage Fish Task Force in August and maintains its original position. Additionally, none of the *ad hoc* approaches will allow for an evaluation of the tradeoffs between management objectives for menhaden and predators without the development of a multispecies MSE framework and forward projections of a multispecies model.

The BERP WG will present these recommendations for approval and tasking from the Atlantic Menhaden Management Board at its November 3rd meeting. Once approved, the BERP WG will move forward with the assessment process.

For more detailed information, please see the Ecosystem Management Objectives Workshop Report, the October meeting summary of the BERP Workgroup, and the April BERP WG memo on the ASMFC website: http://www.asmfc.org/species/atlantic-menhaden.

Table 1: BERP WG recommended modeling approaches to develop ERPs for Atlantic menhaden and the fundamental objectives they address.

	FUNDAMENTAL OBJECTIVES										
	Sustain menhaden to provide for fisheries				**Sustain menhaden to provide for predators**				**Provide stability for all types of fisheries**		
	PERFORMANCE MEASURES										
	Abundance/ biomass of menhaden	Menhaden yield objectives	Age Composition	Historical distribution (Age comp as proxy)	Abundance/ biomass of predators	Predator yield objectives	Predator nutrition	Prey availability relative to predator distribution	Stability in yield for directed menhaden fisheries	Stability in yield for non-menhaden fisheries	**Timeline for Management Use**
Single-Species Models											
BAM Statistical Catch-at-Age Model (current model)	X	X	X	X					X		Ready now
Multi-Species Models											
Surplus Production											
Steele-Henderson	X	X					X (proxy)		X		6 months-1 year, 2-3 years for committee review, peer review
Catch-at-Age											
Multi-species Catch-at-Age (MSSCA)	X	X	X	X	X	X	X (proxy)	*	X	X	1 year to finalize model, 2-3 years for committee review, peer review

*: Possible to develop a spatially-explicit version of the model that would meet that performance objective, but would require extensive additional work (10+ yrs)

The WG also recommends that ecosystem indicators such as forage indices and predator nutrition be monitored as part of a comprehensive ecosystem approach.
Progress on additional ecosystem models being developed by outside groups (e.g., time-varying r, Ecopath with Ecosim) should also be monitored.

References:

[1] Pikitch, E., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Essington, T., Heppell, S.S., Houde, E.D., Mangel, M., Pauly, D., Plagányi, É., Sainsbury, K., and R.S. Steneck. (2012). Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp.

[2] Patterson, K. 1992. Fisheries for small pelagic species: an empirical approach to management targets. Rev. Fish Biol. Fish., 2:321-338

[3] Walters, C. J., and Martell, S. J. D.. 2004. Fisheries ecology and management. Princeton University Press, Princeton and Oxford. 399 pp.

[4] Guénette, S., Melvin, G., and Bundy, A. 2014. A review of the ecological role of forage fish and management strategies. Can. Tech. Rep. Fish. Aquat. Sci. 3065

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Atlantic States Marine Fisheries Commission
BERP Workgroup Meeting

October 6-7 2015

Draft Summary

BERP WG Members: Matt Cieri, Jason McNamee, Amy Schueller, Howard Townsend, Jim Uphoff, Dave Chagaris, Jeff Brust, Mike Celestino, Alexei Sharov

Staff: Mike Waine, Shanna Madsen, Katie Drew, Kristen Anstead

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1. Updates on ERP Options
   a. Ecosystem modeling: EwE *(A.Buchheister)*
   b. MSSCAA model *(J. McNamee)*
   c. Bayesian approach w/ varying r *(S. Madsen filling in for G. Nesslage)*

Andre B. updated the group on his EwE model.

- EwE model: 1982-2013; continental shelf from NC to ME (not spatially explicit); 61 groups (plankton to whales); 8 groups with multiple age classes. Menhaden have 22 predators and feed on 6 prey groups in the model.
- Performance measures: biomass of predators, fishery yields, number of trophic groups depleted and pred:prey ratios
- 50-year EwE projections made after adjusting Menhaden F (all other parameters are constant).
- Previously, had an unexpected finding (presented at AFS) that striped bass abundance was relatively higher at high menhaden F relative to when menhaden F was low. This was due to 1) relatively high consumption of striped bass by dogfish and 2) a crash in striped bass irrespective of menhaden fishing. The dogfish diets had included NEAMAP but not NEFSC data (in nearshore environment spiny dogfish eat striped bass; less so offshore). Fixed dogfish issues and striped bass crash by updating diets, reducing biomasses, and adjusting model parameters.
- With these adjustments, striped bass and bluefish biomass and yield are declining with menhaden removal. Dogfish “win” in this scenario (because competitors [e.g., striped bass and bluefish] are declining).
- As F on menhaden increases more groups in the model are impacted (impacted by >50% or >90%).

- This model can be used as a tool for assessing tradeoffs through varying menhaden F to see response of the other items in the models
- Various types of uncertainty can be accounted for in this EwE model. Evaluating model uncertainty in EwE: 1) sensitivity runs (MC runs of the model, examine alternative parameterizations). 2) multi-model inference (compare EwE findings with other BERP models). 3) MSE (not planned for this iteration of project). 4) Improve sampling (not planned).
- Timeline: Dec 2015: preliminary results; September 2016: final report and manuscripts to peer review. Andre is taking a job in CA, but will be utilizing a no-cost extension to finish this work.

Jason M asked how feedback in model was accounted for (i.e., declines in menhaden has feedback in ecosystem – how does this work?). Andre B responded that it worked through the EwE foraging arena theory (mitigated through diet data). Matt C asked if there was a mechanism for prey switching. Andre B responded that EwE calculates feeding rates of predators using a multispecies generalization of Holling's type II functional response model. This model allows predators to consume different amounts of prey based on their relative abundances.. There is a vulnerability parameter which is the rate at which the prey are moving between vulnerable and non-vulnerable states. Changes in that parameter shifts the modeling system to more top-down or bottom-up driven. Andre B noted that this parameter is tuned as part of the fitting process (to match observed data) and then projected forward and assumed to remain constant. There is no way to empirically measure vulnerability parameter and the model can be sensitive to this parameter. Micah D asked how sensitive the metrics were to changes in the dogfish data. Andre B noted the model is sensitive to dogfish diet. Striped bass biomass declines or increases depending upon the diet data. A change of ~5% in dogfish diet had a dramatic result because there are so many dogfish in the ecosystem – but note too that striped bass was crashing even with the dogfish diet change. Andre B noted that any unID fish in diets were proportioned out amongst IDed fish prey.

Jason M updated the group on his MSSCAA model.

- The MSSCAA model allows the addition of uncertainty, which is important for species with a high recreational component and age structured modeling.
- SCAs are connected through use of predation functions – currently feedback in the model is a one way street: predators increase and that results in a decrease in prey, but prey declines currently do not result in predator declines.
- Model estimates F, selectivity, 1st year abundance, annual recruitment, survey catchability. Food selection parameters (species preference, size preference) are estimated externally. Predation is a function of predator abundance, prey biomass, and prey suitability.
- Spatial overlap is not accounted for in the current model except through the prey preference parameter. We could build in spatial explicitness as an extension. Cannibalism can also be added later.
- Model ecosystem: Striped bass, bluefish, weakfish, menhaden, and scup.

- In development – a) extension of Curti et al model: reintroduced selectivity functions (double logistic); b) developed projection capabilities: currently focused on menhaden and striped bass; c) developing feedback loop: again focused on striped bass and menhaden, focusing on projection module, but will attempt to base estimation on model. The feedback is currently in one direction and we ultimately need to have two-way feedback to use the model for management.
- The feedback module is based on Gislason 1999. Concept is that growth of predators is dependent of available biomass prey. Modification of feedback model is needed due to how overall ecosystem biomass is treated. Though the outcome may be that relationship is undetectable (striped bass are not a highly dependent predator, so if menhaden decline, striped may not necessarily decline: they can switch to other prey items).
- Timeline: Through the end of the year, complete projections and feedback loop. Early 2016 for dissertation defense.

Mike C said he recalled trying to plug feedback loops into the MSVPA, but thought we did not have the data. Jason M responded that the parameterization is not as complex, if a relationship exists and can be detected in the data, we can parameterize the feedback loop. Alexei S noted that the M2 from the MSSCAA is model is lower than MSVPA M2. He questioned if there were differences in suitability and spatial overlap. Jason M responded that he will improve diet information (and not just rely on NEFSC) which could lead to differences in what we're currently seeing. Mike C asked if you could incorporate non age structured prey/pred in MSVPA, like sand lance. Jason M responded that it was definitely a possibility, but not an insignificant amount of work.

Shanna M provided a quick update on Genny N's surplus production model with time varying r.

- They will be receiving the MD Sea Grant funding
- Genny is able to try modifying/testing their model however needed if BERP decides to include it in the modeling approaches.
- She and Mike have a menhaden/striped bass simulation model that could be used to compare model/ERP performance if BERP finds that approach useful.

2. Update on Ecosystem Management Objectives Workshop *(M. Cieri)*

See Ecosystem Management Objectives Report for complete update.

3. Identify intersection between management objectives and available BERP WG models
    a. Pair analytical tools to address management objectives
    b. Discuss model development timeframe, peer review, set realistic timelines
    c. Repopulate Table 1 and 2 from "*Ecological Reference Points for Atlantic Menhaden*
    d. Prepare recommendations for Atl. menhaden Board

The group repopulated Table 1 and 2 from the "Ecological Reference Points for Atlantic Menhaden" Report. The new table 2 matches fundamental management objectives from the

EMOW and performance measures and the new table 1 has updated timelines. These tables can be found below.

- The group removed empirical ERPs (such as Lenfest-recommended ERPs) from the table because these are reference points and management actions, not a model that can be projected forward. E.g., 0.75B0, 0.8B0, 0.5Fmsy, 1-(0.5*M) (ICES). This item differs from the others models in that it is a possible "answer" or reference point, whereas the models in the table are used to generate an answer/reference point. How modeling approaches determined a reference point would be dependent on how you weight your management objectives. With these empirical ERPs (based on meta-analyses of multiple systems), the objectives are general and you are locked in on an ERP. These empirical reference points could be evaluated with forward projections of the other modeling approaches in the table.
- The group also removed BAM Management Strategy Evaluations (MSE) from the table. MSEs can be applied to any of our models to evaluate management actions. MSEs may also help provide management stability if management actions are performing well. A MSE approach will be part of the BERP recommendations to the AM Board.
- The group removed MSVPA/MSSCAA-BAM projection reference points because it was not functioning properly when we tested the method using the MSVPA. There was discontinuity between the BAM and MSVPA. This method did not offer anything additional from the single species model. MSSCAA will have the capability to do projections, so there is no reason to plug it back into another SCA.
- The group removed the single-species model with a time-varying M tuned to the consumption index because it provided nothing additional from the single-species model.
- The committee discussed the pro/cons of the MSVPA vs using the MSSCAA. With the MSVPA, we've used it multiple times so the committee understands the strengths and weaknesses, but with the new model it would take some time for us to run through iterations and become comfortable with it. However, the MSVPA was very sensitive to spatial and type preferences, and we had to tune it to fix strong preference for benthic inverts and zooplankton. There was also divergence in the model outputs. It should also be moved into something more "usable" than visual basic. The MSSCAA is much less labor intensive, you don't have to explicitly model everything that is in the ecosystem. Its framework is also more user friendly and allows for the addition of uncertainty (unlike the MSVPA). The committee was in favor of pursuing the MSSCAA over the MSVPA as a multispecies modeling tool, but as we are unsure of model performance yet and the MSSCAA still needs some development, we left the MSVPA on the table as a backup.
- On the first day, the group decided that ecosystem indicators (such as Chl a, forage indices, predator:prey ratios etc.) should be removed from the table as they do not meet any of the performance metrics or fundamental objectives alone. The BERP decided that they are most useful when used in conjunction with models that are able to provide predictions. They are empirical measures (index of abundance, etc) that can be updated every year to give

managers a sense of how their management is performing. Since some of these indicators (predator:prey ratio, forage indices) could come from other modeling inputs, they would be minor updates that could be performed fairly easily.

- On the second day, a minority of the committee (Alexei S and Jim U) requested that the ecosystem indicators be considered as standalone alternatives to the other modeling approaches. In this approach, the indicators would be used to develop control rules and trigger management action.
- The majority of the committee did not believe ecosystem indicators were able to be robust, defensible control rules, but preferred using them as a "rumble strip" to indicate when we need to use our modeling tools to check on the system and to provide context for managers and give them a biological indication of how management measures are performing. Many committee members noted that we need to be realistic about what we can actually accomplish with the other tasks we have and the time we have to accomplish them. If we were to explore these ecosystem indicators as control rules, other modeling approaches will suffer. They believed it would be more fruitful to focus on other multispecies and production model approaches as these were able to address multiple objectives and performance measures and had predictive capabilities.
- The committee agreed that these indicators could still be useful in providing context, and even provide some of the more abstract management objectives such as "Achieving broad public support for management" because they are easily understood.
- The majority of the committee requested that the minority provide examples on how some of these indicators would be translated into a control rule (i.e., need to be able to answer: If the index is at level x, how does that affect menhaden F?). From these examples the committee will come to a final decision on whether to treat ecosystem indicators as a "rumble strip" to provide context or to use them in a standalone control rule. Jim U mentioned that he had a Chesapeake Bay example that he would provide at the next BERP meeting.
- The BERP Committee also revisited the timelines for model development. Please see the model timeline table.
- Based on committee deliberations, the BERP decided to pursue two models, Steele-Henderson and MSSCAA. The committee could not reach consensus on how to proceed with the ecosystem indicators and will reevaluate these at the next meeting when they can review an example of indicators as a control rule.
- Outside models such as EwE (Andre B) and the production model with time-varying r (Genny N) will be explored and compared to BERP modeling efforts as appropriate during the process. Since these are not a draw on committee time, the BERP agreed that the findings from these models would be useful to compare to BERP-models. These models will hopefully be complementary to the BERP models and provide a check on model outcomes.
- The group agreed that ERP models and approaches should be packaged as a suite of approaches and peer reviewed together. The committee agreed this would be the best use of the peer reviewer's time to look at all models all at once so that they can make comparisons.

- The BERP will recommend that the Board continue using the current single-species BAM model for BRPs to manage the stock in the interim while ERPs are developed.
- The committee will provide their recommendations to the Board in November in the form of a presentation and a memo. These recommendations will involve timelines and realistic expectations for when models and approaches will be ready for management. Matt C will work with staff to produce both.

		Ecosystem Indicators				Single-Species Models		Multi-Species Models: Surplus Production		Multi-Species Models: Catch-at-Age		
Fundamental Objectives	**Performance Measures**	Predator: Prey Ratios	Environ-mental indicators	Forage indices	Nutrition Reference Points	BAM (current model)	Single-species model with time-varying M tuned to consumption index	Steele-Henderson	Time-varying r	MSVPA/MSSCA + BAM projections	Multi-species Statistical Catch-at-Age (MSSCA)	Ecopath with Ecosim (EwE)
Sustain menhaden to provide for fisheries	Abundance/ biomass of menhaden					x	x	x	x	x	x	x
	Menhaden yield objectives					x	x	x	x	x	x	x
	Age Composition					x	x			x	x	x
	Historical distribution (Age comp as proxy)					x	x			x	x	x
Sustain menhaden to provide for predators	Abundance/biomass of predators									x	x	x
	Predator yield objectives									x	x	x
	Predator nutrition				x (direct)			x (proxy)		x (proxy)	x (proxy)	x (proxy)
	Prey availability relative to predator distribution					*	*			*	*	*
Provide stability for all types of fisheries	Stability in yield for directed menhaden fisheries					x	x	x	x	x	x	x
	Stability in yield for non-menhaden fisheries									x	x	x
	Frequency of management action											
Sustain menhaden to provide for historical and cultural values *(Needs relationship btw proxies and employment defined through socioecon analysis)*	Proxies: Abundance/biomass, yield, and age composition of menhaden					*	*	*	*	*	*	*
	Proxies: Abundance/biomass and yield of predators									*	*	*
Minimize risk to sustainability due to changing environment *(Needs environmental relationships defined)*	Model must explicitly consider uncertainty about future environment for menhaden					*	*	*	*	*	*	*
	Model must explicitly consider uncertainty about future environment for predators									*	*	*
Achieve broad public support for management	Measures of public support											
Sustain ecoystem resiliency or stability												x

x: Indicates the model currently meets or future iteration of the model will meet the performance measure

*: Indicates it is possible to modify the model to meet that performance objective, but would require extensive additional work

Grayed out models were removed by the committee, see summary for details

APPROACH	BRIEF SUMMARY OF ERP/EBFM PRODUCTS	TIME REQUIRED TO DEVELOP
Ecosystem indicators	EBFM monitoring tool	6 months, annual updates
Nutrition Ref Points	ERPs for prey and predators, EBFM monitoring tool	1-2 months for MD existing program focused on striped bass. **Additional data collection program for the coast required. 1 yr for striped bass program development and 1-2+ yrs for pilot studies for other predator species**
Production models		
Steele-Henderson	MSY-based ERPs for menhaden, consumption estimates	6 months-1 year, 2-3 years for committee review, peer review
Time-varying *r*	MSY-based ERPs for menhaden	6 months-1 year, 2-3 years for committee review, peer review
Single-species models		
BAM	SPR-based ERPs for menhaden	Completed
Multi-species models		
MSSCAA or MSVPA	Forage services ERPs for menhaden, consumption estimates	1 year to finalize model, 2-3 years for committee review, peer review
Ecopath with Ecosim	Forage services ERPs for menhaden, consumption estimates	1 year to finalize model and submit manuscripts for publication, 2-3 years for committee review, peer review