Atlantic States Marine Fisheries Commission
Atlantic Menhaden Technical Committee

Alternative Reference Point Guidance Document

March 2011

BACKGROUND

At its May 2010 meeting, the Menhaden Board passed a motion tasking the Menhaden TC to develop alternative reference points. In addition, the Policy Board directed the Multispecies TC to be available to work with the Menhaden TC to explore reference points that account for predation. The Board asks the TC to complete the following tasks:

A. Develop a suite of alternative biological reference points, including:
    1. Spawning stock biomass or population fecundity relative to the unfished level
        a. Develop a range of associated SSB threshold and target options, using other clupeid and forage fish species as reference
    2. An abundance-based reference point
    3. Evaluate whether an F-based reference point is appropriate for menhaden
        a. If not appropriate, present justification for discontinuing its use
        b. If appropriate alternatives exist, present new options

B. List pros and cons of alternatives for use in management.

C. Conduct projections of abundance, spawning stock biomass, or population fecundity for alternatives where projections are appropriate.

D. Work with the MSTC in developing alternative reference points that account for predation on menhaden and provide guidance to the Board

E. Develop a range of management strategies that can be used to achieve these reference points (e.g., coastwide cap).
    a. Include workload demands of the Technical Committee(s) associated with each management strategy

A suite of alternative reference points for Atlantic menhaden has been prepared by the Atlantic menhaden Technical Committee and the Multispecies Technical Committee and are outlined in this document. Each alternative reference point approach has the potential to provide different management advice. The purpose of this paper is to facilitate decision-making by outlining the specific management goals, potential benefits, and caveats for each reference point approach.

The menhaden TC identified three potential management goals that may be addressed by this suite of alternative reference points. A description of each approach can be found in the next section. The three potential management goals are:

Goal 1: Increase abundance and spawning stock biomass of menhaden for the benefit of the stock (a "single-species focus")
Goal 2: Increase recruitment of menhaden for the benefit of the stock (a "single-species focus")
Goal 3: Increase forage base for predators of menhaden (an "ecosystem approach")

One or more of these goals may be achieved through the suite of reference point approaches discussed below. If the Board has additional management goals, the TC can provide guidance on how to achieve those goals once they have been clearly identified.

REFERENCE POINT APPROACHES

Maximum Spawning Potential (MSP)

Task: The Board charged the TC with calculating the fishing mortality rate associated with current (9%), 15%, 25%, and 40% maximum spawning potential (MSP).

Description: A maximum spawning potential (MSP) approach identifies the fishing mortality rate necessary to maintain a given level of stock fecundity relative to the potential maximum stock fecundity under unfished conditions. For example, if the Board were to set an MSP goal of maintaining status quo (9% MSP), the TC could provide an estimate of the fishing mortality rate threshold ($F_{9\%}$) required to maintain approximately 9% of virgin stock fecundity. These reference points are sometimes also referred to as "spawner per recruit (SPR)" reference points

Primary goal addressed:
Goal 1: Increase abundance and spawning stock biomass of menhaden for the benefit of the stock (a "single-species focus")

Potential benefits:
1. The adoption of higher %MSP threshold reference points (lower fishing mortality) should result in higher abundance and spawning stock biomass with slightly lower landings than have been reported in recent years (see SPR projection reports).
2. This approach may also address **Goal 2**. Over the period of known exploitation, menhaden recruitment appears to be independent of fishing mortality and spawning stock biomass, indicating environmental factors may be the defining factor in the production of good year classes. If menhaden recruitment is largely environmentally driven, adoption of an MSP approach may not result in better recruitment. However, there is a possibility that the stock may be able to take greater advantage of favorable environmental conditions if a larger percentage of spawning adults remain in the population.
3. This approach may also address **Goal 3**. If abundance and biomass of the stock increases, the forage base for predators of menhaden should increase. However, an increase in forage does not always imply increased consumption by predators since predator-prey interactions are governed by a suite of other biological and

ecological factors. And note that MSP reference points cannot be used to provide formal insight about ecosystem benefits other than the notion that higher % levels of MSP should provide greater ecosystem benefit and lower % levels of MSP will likely provide greater benefit to the fishery.

Caveats:

1. An MSP approach assumes no changes are occurring in the stock's biomass, fishery selectivity, fecundity, and natural mortality-at-age (i.e. equilibrium conditions will be maintained). Given the many changes this stock has undergone in the last few decades, the TC is concerned that this assumption will likely be violated and the MSP reference points could generate misleading management advice. Therefore if the Board chooses to adopt MSP reference points, ***the TC advises the Board to use results based on the most recent years of input data***, recognizing that they may not be representative of the entire time series.
2. If the Board chooses to implement an MSP management scenario, the TC believes annual quota estimation and stock assessment updates would be ideal. An increase in assessment frequency is likely not possible in the foreseeable future, which implies that quota setting for "off" years will have to be based on the most recent assessment and projection analyses.
3. An MSP approach can provide overfishing definitions, but will not yield overfished definitions.

ACTION: If an MSP reference point approach is selected, the Board will need to choose an MSP level (percentage) threshold and target (if desired). Stock projections assuming different levels of %MSP and recruitment have been provided.

Abundance-based approach

Task: The Board charged the TC with developing abundance-based reference points.

Description: Here abundance-based reference points are defined in terms of total number of menhaden. This approach typically involves the ad hoc selection of a reference time period during which some measure of stock abundance (usually the median number) is considered adequate by managers. Current abundance is then compared with the reference measure of stock abundance to determine if it has the population has declined to an unsatisfactory level.

Two abundance-based approaches were considered by the TC. The first approach was a simple set of comparisons between the estimated number of menhaden in 2008 relative to median conditions observed over the last 10 and 30 years for age classes 0, 1, and 3+. The second approach explored the use of the coastwide aggregated juvenile abundance index as a predictor of the adequate population size necessary to avoid recruitment failure (Butterworth and Redemeyer report). The TC reviewed the approach presented by Butterworth and Rademeyer and determined that it could serve as a viable tool for

preventing recruitment failure and could be adjusted to reflect desired management objectives. Both methods would provide overfished definitions of stock status.

Primary goal addressed:
Goal 1: Increase abundance and spawning stock biomass of menhaden for the benefit of the stock (a "single-species focus")

Potential benefits:

1. The adoption of ad hoc abundance threshold reference points (a result of lowering fishing mortality) should result in higher abundance and spawning stock biomass.
2. Abundance-based reference points have the potential to address **Goal 2**. As described above (MSP section), adoption of an abundance-based reference points may not result in better recruitment. However, there is a possibility that the stock may be able to take greater advantage of favorable environmental conditions if a larger percentage of spawning adults remain in the population.
3. If ad hoc reference points based on ages 0 or 1 are chosen, management will be focused on maintaining abundance of young fish, potentially at the expense of managing for spawning stock biomass. If ad hoc reference points based on ages 3+ are chosen, then all fish are considered equal, not accounting for increased fecundity with age. However, an age 3+ reference point would provide a better index of spawning stock than reference points based on ages 0 or 1.
4. Abundance-based reference points may also address **Goal 3**. As described above (MSP section), the forage base for predators of menhaden should increase if abundance and biomass of the stock increases. Ad hoc reference points based on ages 0 or 1 would provide an index of forage availability for predators of menhaden. However, as described above, abundance-based reference points cannot guarantee increased predation by predators or be used to quantify changes in forage availability or consumption rates.

Caveats:

1. There is not a strong biological basis for using abundance-based reference points since menhaden egg production increases with fish size/age. In theory, recruitment should be more directly related to total fecundity or total spawning stock biomass since not all menhaden are equivalent in terms of the number of eggs produced in any given year. The stock-recruitment relationship defined as recruits related to numbers of mature menhaden showed no clear pattern (i.e., no improvement when compared to recruits as a function of fecundity), so this approach does not appear to confer a significant advantage over status quo. If management objectives are focused on prevention of recruitment failure, then the Butterworth and Rademeyer approach may prove viable. However, if management is designed to protect spawners for the purpose of perceived gains in future recruits, then the TC recommends that great caution be exercised with the use of abundance-based reference points.
2. An abundance-based approach does not provide an overfishing definition.

ACTION: If simple ad hoc abundance-based reference points are adopted, the Board will need to choose an abundance reference period (e.g. 10 vs. 30 years) and an age grouping (e.g. 0, 1, 3+) to define the threshold and target. If the Butterworth and Rademeyer approach is adopted, the time period across which the JAI should be examined would need to be selected to identify the most conservative limit reference point.

Multispecies approach

Task: The Board requested the TC provide an evaluation of the suite of multispecies reference point and modeling approaches provided by the Multispecies Technical Committee.

Description: The menhaden TC reviewed four modeling approaches for generating menhaden reference points that explicitly include predation effects. The two methods suggested by the menhaden TC for short-term implementation are described below (see handout for TC comments on all four approaches).

1. *Multispecies Virtual Population Analysis*: The MSVPA models population dynamics of striped bass, weakfish, bluefish, and menhaden while estimating the predation effects of these three major predators on menhaden. In its present state, the MSVPA can be used to develop predator-prey ratios and estimates of food availability (menhaden) as reference points or triggers. It is also available for management strategy evaluation. If the Board were to adopt ecological reference points (**Goal 3**), the MSVPA was deemed the most viable option that has been presented to the TC.
2. *Steele-Henderson model*: The Steele-Henderson approach uses a biomass dynamic (age-aggregated) model to estimate menhaden dynamics with the addition of predator biomass as an index that is negatively related to menhaden abundance. The menhaden TC suggested that the Steele-Henderson be run as a secondary model to the MSVPA if ecosystem reference points were adopted by the Board. The TC felt that comparing results from the Steele-Henderson model with that of the MSVPA would be instructive; similarities between models would provide additional support for estimated trends, whereas differences between models would help identify key assumptions in one or both models that may be violated.

Primary goal addressed:
Goal 3: Increase forage base for predators of menhaden (an "ecosystem approach")

Potential benefits:

1. *Multispecies Virtual Population Analysis*: The MSVPA explicitly incorporates all known sources of diet and abundance information for menhaden and its major predators. Also, the model has been peer-reviewed and updated recently by the Multispecies TC. Output from the MSVPA can be used to develop biological reference points that account for predation.

2. *Steele-Henderson model*: In addition to providing an alternative approach to estimating menhaden dynamics in the presence of predation, the Steele-Henderson model has the potential to generate non-equilibrium maximum sustainable yield-based reference points.

Caveats:

1. MSVPA: The Multispecies TC would need additional time to develop appropriate reference points or triggers based on objectives defined by the Board. The model should be regularly updated when new stock assessment and diet information become available. The MSVPA is limited in terms of the number of modeled predators and additional model development would be necessary to provide estimates of uncertainty.
2. Steele-Henderson model: Reference points have not yet been generated, although doing so is possible. The model relies on comparison of predator indices, not on diet information or explicitly modeled predator-prey dynamics. This particular application of the Steele-Henderson model for menhaden would benefit from additional refinement and testing before use in management, including the exploration of additional available indices for key species in the model.

ACTION: If multispecies reference points are adopted, the Board will need to quantify its goals for establishing predator-prey ratio threshold or triggers and the magnitude of the desired increase in forage availability. The Board will also need to identify the predator species of interest since additional model development would be necessary to include species other than those considered thus far.