# DRAFT “EXECUTIVE SUMMARY”

# OF THE 2018 ATLANTIC HERRING STOCK ASSESSMENT

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**This is an excerpt from a DRAFT stock assessment report being prepared for SARC 65. This stock assessment has not been peer reviewed yet. As such, this Draft Summary has no official status with NOAA Fisheries and does not represent any final agency determination or policy.**

The SAW/SARC 65 Atlantic Herring Working Group conducted a Data meeting (February 6-7, 2018) and a Model meeting (May 2-4, 2018) in the development of this assessment. The SAW/SARC Herring Working Group members are:

Jon Deroba – NEFSC Population Dynamics (Assessment lead)

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## Executive Summary

***TOR B1.*** *Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize uncertainty in these sources of data. Comment on other data sources that were considered but were not included.*

US catches were developed for the years 1965-2017 and were a sum of landings and self-reported discards. Discards have only been available since 1996, but were generally less than 1% of landings. Consequently, discards do not represent a significant source of mortality and a lack of historical discards is not considered problematic for the assessment. US catches were developed separately for fixed and mobile gear types. Catches from the New Brunswick, Canada, weir fishery were provided for the years 1965-2017 and were added to the US fixed gear catches for the purposes of assessment.

Total catches during 1964-2017 ranged from 44,613 mt in 1983 to 477,767 mt in 1968. Total catches during the past five years ranged from 50,250 mt in 2017 to 101,622 mt in 2013 and averaged 79,206 mt. Mobile gear catches have been the dominant gear type since about 1995.

***TOR B2.*** *Present the survey data being used in the assessment (e.g., regional indices of abundance, recruitment, state surveys, age-length data, food habits, etc.). Characterize the uncertainty and any bias in these sources of data.*

Abundances (i.e., arithmetic mean numbers per tow) from the NMFS spring, fall, and summer shrimp bottom trawl surveys were used in the assessment model along with annual coefficients of variation and age composition when they were available. The trawl door used on the spring and fall surveys changed in 1985 and likely altered the catchability of the survey gear. Consequently, the spring and fall surveys were split into two time series between 1984 and 1985, and these were treated as separate indices in assessment models. The spring and fall surveys also used a different vessel (i.e., the Bigelow) beginning in 2009, and so these surveys were split again to account for this vessel change. Ultimately, the spring and fall surveys had three time stanzas: 1965-1984, 1985-2008, 2009-2017.

An acoustic index collected during the NMFS fall bottom trawl survey was also used as an index of herring abundance. This survey has no age composition data and so selectivity was knife-edged at age-3.

Several other indices of abundance were considered, but not used in the final assessment model. These indices included: NMFS winter survey, Massachusetts state surveys (spring and fall), joint Maine/New Hampshire state surveys (spring and fall), and an index based on food habits data.

***TOR B3.*** *Estimate consumption of herring, at various life stages. Characterize the uncertainty of the consumption estimates. Address whether herring distribution has been affected by environmental changes.*

Fish food habits data from NEFSC bottom trawl surveys were evaluated for 12 herring predators. From these data, diet composition of herring, per capita consumption, and the amount of herring removed by the 12 predators were calculated. Combined with abundance estimates of these predators, herring consumption was summed across all predators as total herring consumption. Annual removal of herring amounted to 10s to 100s of thousands of mt by these predators. Annual removal ranged from 32,700mt in 1983 to 390,000mt in 2008. Amount of deaths due to input natural mortality in the stock assessment were compared to the estimates of predatory consumption as a general check of scale.

***TOR B4.*** *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Incorporate ecosystem information from TOR B3 into the assessment model, as appropriate. Include retrospective analyses (both historical and within -model) to allow a comparison with previous assessment results and projections, and to examine model fit.*

The base ASAP model made structural changes to the previous assessment (e.g., M, selectivity), included new index time series, and re-evaluated some other relatively minor issues (e.g., weak likelihood penalties). Of particular importance, however, was a change to M. Natural mortality in recent assessments varied by time and age, with values based on a combination of the Hoenig and Lorenzen methods (Hoenig 1983; Lorenzen 1996). In 2012, the natural mortality rates during 1996-2011 were increased from these base rates by 50% to resolve a retrospective pattern and to ensure that the amount of herring deaths due to input M were consistent with observed increases in estimated consumption of herring. In 2015, a retrospective pattern re-emerged and implied levels of consumption were no longer consistent with estimated consumption. Thus, assumptions about time- and age-varying M were reevaluated as part of this assessment. Ultimately, M equaled 0.35 for all years and ages in this assessment.

The base ASAP model estimated SSB in 2017 to be 141473 mt, with SSB ranging from a minimum of 53,084 mt (1982) to a maximum of 1,352,700 mt (1967) over the entire time series. The base ASAP model estimated total January 1 biomass in 2017 to be 239,470 mt, ranging from a minimum of 169,860 mt (1982) to a maximum of 2,035,800 mt (1967) over the entire time series.

No common age is fully selected in both the mobile and fixed gear fishery. Consequently, the average F between ages 7 and 8 was used for reporting results related to fishing mortality ($F_{7-8}$), and this includes reference points. These ages are fully selected by the mobile gear fishery, which has accounted for most of the landings in recent years. $F_{7-8}$ in 2017 equaled 0.45. The all-time low of 0.13 occurred in 1965. The all-time high of 1.04 occurred in 1975.

Age-1 recruitment has been below average since 2013. The all-time high of 1.4 billion fish occurred in 1971. The estimates in 2009 and 2012 are still estimated to be relatively strong cohorts, as in previous assessments. The all-time low of 1.7 million fish occurred in 2016, and the second lowest of 3.9 million fish occurred in 2017. Four of the six lowest recruitment estimates have occurred since 2013 (2013, 2015, 2016, 2017).

The internal relative retrospective pattern suggested consistent overestimation of SSB with Mohn's Rho = 0.15, and underestimation of $F_{7-8}$ with Mohn's Rho = -0.11. The retrospective pattern for recruitment at age 1 was characterized by both positive and negative peels. The presence of the retrospective pattern was sensitive to the indices of abundance used in the model. The retrospective pattern was not severe enough, however, to warrant an adjustment for stock status determination or projections. Estimating catchability separately for the Bigelow years in 2009-2017 may also be aliasing other causes of the retrospective pattern, and so future herring assessments may have worsening retrospective patterns.

***TOR B5.*** *State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for* $B_{MSY}$*,* $B_{THRESHOLD}$*,* $F_{MSY}$ *and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.*

The existing MSY reference points were based on the fit of a Beverton-Holt stock-recruitment relationship, estimated internally to the ASAP model, and inputs (e.g., weights-at-age, natural mortality) from the terminal year of the assessment (i.e., 2014). Point estimates of the MSY BRPs equaled: MSY = 77,247 mt, $F_{MSY}$ = 0.24, and $SSB_{MSY}$ = 311,145 mt.

No stock-recruit relationship was able to be estimated in this assessment, therefore $F_{40\%}$ was used as a proxy for $F_{MSY}$ and long-term projections were used to derive other MSY BRP proxies. $F_{MSY}$ proxy = 0.51, $SSB_{MSY}$ proxy = 189,000 mt (½ $SSB_{MSY}$ = 94,500 mt), and MSY proxy = 112,000 mt.

The existing MSY reference points were based on estimates of a Beverton-Holt stock-recruit curve fit internally to the ASAP model. The ability to estimate the stock-recruit curve seems to have deteriorated in this assessment, but the ability of previous models to estimate a stock-recruit curve has also been noted as tenuous. The newly proposed reference points no longer rely on a poorly estimated stock-recruit relationship.

***TOR B6.*** *Make a recommendation about what stock status appears to be based on the existing model (from previous peer reviewed accepted assessment) and based on a new model or model formulation developed for this peer review.*

*a. Update the existing model with new data and evaluate stock status (over fished and overfishing) with respect to the existing BRP estimates.*

Given the Working Group's conclusion that MSY reference points based on the estimation of a stock-recruit curve were unjustified, and were likely unjustified in previous assessments, the existing BRPs are not meaningful.  Similarly, evaluating stock status of the existing model with updated data to the existing MSY BRPs is not informative.

*b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR B5).*

The base ASAP model estimated $F_{7\text{-}8}$ in 2017 to be 0.45 and SSB in 2017 was 141,473 mt.  Since the retrospective adjusted values do not fall outside of the confidence intervals of the base model estimates, no retrospective adjustment was warranted. A comparison of the base model values to the new MSY proxy reference points suggest that overfishing is not occurring and that the stock is not overfished.  The error bars for $F_{7\text{-}8}$, however, included overfishing.

*c. Include descriptions of stock status based on simple indicators/metrics.*

The estimated numbers at age in 2017 indicate that the population is characterized by more age 6 fish than age 1 and age 2 combined.  This result suggests a reliance on the ageing 2011 cohort (age 6 in 2017).  If the estimated record low recruitments in recent years hold true, then the SSB is likely to remain relatively low and put the stock at relatively high risk of becoming overfished.  Without improved recruitment, the probability of overfishing under recent catch levels is also likely relatively high.

***TOR B7.*** *Develop approaches and apply them to conduct stock projections.*

*a. Provide numerical annual projections (through 2021) and the statistical distribution (i.e., probability density function) of the catch at $F_{MSY}$ or an $F_{MSY}$ proxy (i.e. the overfishing level, OFL) (see Appendix to the SAW TORs). Each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).*

Short-term projections of future stock status were conducted based on the results of the base ASAP model.  The projections did not account for any retrospective pattern because the Mohn's Rho adjusted values for stock status were within the 80% probability intervals of the 2017 point estimates of $F_{7\text{-}8}$ and SSB.  If the Allowable Biological Catch (ABC) is fully utilized in 2018 (i.e., 111,000mt), then catch at $F_{MSY}$ proxy in 2019=13,700mt, 2020=31,000mt, and

2021=55,700mt. If only half the ABC is utilized in 2018 (i.e., 55,000mt), then catch at $F_{MSY}$ proxy in 2019=28,900mt, 2020=38,000mt, and 2021=59,400mt. As with the catches, future short-term stock status was also sensitive to the catch specified in 2018.

*b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions. Identify reasonable projection parameters (recruitment, weight-at-age, retrospective adjustments, etc.) to use when setting specifications.*

The Working Group agreed that the 2018 ABC of 111,000mt is unlikely to be fully utilized and that some lower value was more realistic, but that value is likely best determined by a technical group of the New England Fishery Management Council. The projections assumed that future recruitment will approach the mean for the time series (1965-2015). If recruitment continues to be below average, the projected catch increases may be overly optimistic.

*c. Describe the stock's vulnerability (see "Appendix to the SARC TORs") to becoming overfished, and how this could affect the choice of ABC (or DEF, possibly even GH&I).*

The unknown contributions of the Scotian Shelf (4WX), Gulf of Maine, and Georges Bank stocks can affect the stocks vulnerability to becoming overfished. The vulnerability of the stock has been demonstrated by the historical collapse of the Georges Bank component in the 1980s, which also demonstrated that the multiple spawning groups can be differentially impacted by fishing. Varying contributions from the Scotian Shelf (4WX) stock may also contribute to a retrospective pattern (see below).

In the short-term, the relatively poor recruitments in 2013-2017 will increase the vulnerability of the stock to becoming overfished. The 2016 and 2017 cohorts were imprecisely estimated and so estimates of these cohorts may change significantly in either direction in future assessments, and decisions should likely consider this uncertainty. Growth (i.e., weight at age) also continues to be relatively low when compared to the 1990s, and this seems to be a longer-term feature of the stock that also reduces production. The stock, however, seems to be capable of producing relatively large and small year classes regardless of growth, and so recruitment is likely the more significant driver of short-term vulnerability.

While this assessment had a retrospective pattern that did not warrant adjustments (i.e., via Mohn's Rho), the history of the Atlantic herring stock assessment suggests that resolutions to retrospective patterns are ephemeral, and so future herring assessments may have worsening retrospective patterns. Retrospective patterns are indicative of model misspecification, and this would increase the vulnerability of the stock to becoming overfished.

***TOR B8.*** *If possible, make a recommendation about whether there is a need to modify the current stock definition for future assessments.*

Previous assessments concluded that there is likely sub-stock structure unaccounted for in the assessment, but that there is no ability to distinguish mixed survey and fishery catches to stock of origin. This lack of information on stock of origin precludes accounting for the sub-stock structure. An attempt was made to use an assessment model (Stock Synthesis) that accounted for stock structure on a coarse level (i.e., inside and outside of Gulf of Maine), but estimating area-specific recruitment and movement rates required unrealistic assumptions and the model generally performed poorly (e.g., poor convergence). The consequences of not accounting for stock structure are unclear, and therefore the need to modify the stock definition is also unclear. More certain, however, is that changing the stock definition and accounting for stock structure in the assessment is currently not possible. Continued research on the topic is warranted.

***TOR B9.*** *For any research recommendations listed in SARC and other recent peer reviewed assessment and review panel reports, review, evaluate and report on the status of those research recommendations. Identify new research recommendations.*

Research recommendations from previous assessments were reviewed and progress on each updated and documented. Several new research recommendations were developed.