Information relevant to the 2015 Atlantic herring stock assessment and setting catch advice in the absence of an assessment

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Empirical information

Surveys

The NMFS spring, fall, and summer shrimp bottom trawl surveys, with indices of abundance estimated through 2011, were used in the 2012 assessment (NEFSC 2012). These survey indices were updated through 2014 using the same methods as in NEFSC (2012).

The NMFS spring survey indices of abundance declined from the time series high in 2011 to values in 2012-2014 that are similar to the average of the observations from 1985-2014 (Figure 1). The NMFS fall survey indices have varied without trend near the average of the observations from 1985-2014 for about ten years (Figure 1). The indices from the NMFS summer shrimp survey have been near or below the time series average for about eight years (Figure 1). Each of these surveys has a different selectivity pattern, with the spring survey sampling relatively smaller fish than the other surveys, the summer shrimp survey sampling relatively larger fish, and the fall survey an intermediate range of sizes (NEFSC 2012). Consequently, each survey is indexing a different component of the stock complex and so comparing the relative trends among the survey indices should be done cautiously.

The persistence of the 2008 cohort, which was estimated to be the largest in the 1965-2011 time series during the 2012 stock assessment, is evident in the age composition of the spring survey (Figure 2). The 2008 cohort comprised 68% of the spring survey catch as age-4 fish in 2012, 17% of the catch as age-5 fish in 2013, and 16% of the catch as age-6 fish in 2014. The persistence of the 2008 cohort is also evident in the fall survey age composition (Figure 2). The 2008 cohort comprised 54% of the fall survey catch as age-4 fish in 2012 and 36% of the catch as age-5 fish in 2013 (2014 age data not yet available). The 2011 cohort may also be relatively strong. This cohort represented 58% of the spring survey catch as age-2 fish in 2013, and 54% of the catch as age-3 fish in 2014. Likewise, this cohort represented 20% of the fall survey catch age composition as age-2 fish in 2013. No age data are available from the summer shrimp survey.

Fishery Catch

Fishery catches through 2011 were modeled as two fleets, mobile and fixed gears, during the 2012 assessment (NEFSC 2012). These catches were estimated through 2014 using the same methods as in NEFSC (2012). Total fishery catch is controlled by quota and has been relatively stable for about 20 years, averaging 112,000mt (min=80,000mt; max=145,000mt) from 1995-2014 (Figure 3). The persistence of the 2008 cohort is evident in the age composition of the mobile gear fishery (Figure 4). The 2008 cohort comprised 65% of the mobile gear catches as age-4 fish in 2012, 50% of the catch as age-5 fish in 2013, and 22% of the catch as age-6 fish in 2014. The 2011 cohort in mobile gear catches was at least average, representing 16% as age-2 fish in 2013 and 52% as age-3 fish in 2014. The fixed gear fishery catches age-2 Atlantic herring almost exclusively, and so evaluating the persistence of cohorts and relative cohort strength based on the age composition of this gear is difficult (Figure 4). None the less, the 2008 cohort comprised 2% of the fixed gear catches as age-4 fish in 2012 and less than 1% as age-5 and -6 fish in 2013 and 2014. The 2011 cohort comprised 80% of the fixed gear catches as age-1 fish in 2012, which is the largest proportion of age-1 fish caught by the fixed gear fishery in the time series. The 2011 cohort also comprised 73% of the fixed gear catches as age-2 fish in 2013 and 2% as age-3 fish in 2014.

Relative Fishing Mortality

Relative fishing mortality was estimated for the NMFS spring, fall, and summer shrimp bottom trawl surveys by dividing total catch by swept area biomass for each year from 1985-2014 . Each relative fishing mortality time series was rescaled by dividing the estimate in each year by the time series average. These estimates were done using total catch and survey biomass each year for each survey, and by age each year for the spring and fall surveys. Example results are presented for ages 2-5 from the spring and fall surveys because results for other ages were qualitatively similar.

For the spring survey, relative fishing mortality rates were variable with some anomalous year effects. Relative fishing mortality rates based on totals and by age, however, were consistently below average and near all-time lows from 2009-2014 (Figures 5 & 6). For the fall survey, results were similar to the spring survey. Relative fishing mortality rates based on totals and by age were below average and near all-time lows from 2009-2014, with a few exceptions (Figures 5 & 7). For the summer shrimp survey, relative fishing mortality rates varied without trend, except in 1985-1986 which were anomalously high (Figure 5).

Consumption

Predatory consumption estimates of Atlantic herring through 2010 were used in justifying time varying natural mortality that partially resolved a retrospective pattern during the 2012 assessment (NEFSC 2012). Piscivorous fish consumption was estimated through 2013 using the same methods as in NEFSC (2012). Consumption estimates for other predators (e.g., elasmobranchs, highly migratory species, whales, and seabirds) from 2011-2013 equaled the average consumption of these predators from 2006-2010, and the values for other years in the time series were the same as in the 2012 assessment. Total consumption equaled the sum of piscivorous fish and other predatory consumption estimates. Total consumption during 1985-1995 was less than the average total consumption from 1985-2013, higher than the average during 1996-2002, and varied without trend near the average from

2003-2013 (Figure 8). Age composition data are not collected from the diet data used to estimate piscivorous fish consumption.

Stock assessment operational update and issues

The Atlantic herring assessment was updated using data and methods described above and in NEFSC (2012). Briefly, survey and catch data were updated through 2014. Initial age- and year-specific natural mortality rates were estimated using a combination of methods from Lorenzen (1996) and Hoenig (1983). As in the 2012 assessment, these initial rates were increased by 50% from 1996-2014 to reduce the retrospective pattern and reflect the scale and trend of predatory consumption estimates. Input data were weighted (e.g., annual survey coefficients of variation, input effective sample sizes) using the same iterative methods as in NEFSC (2012). An issue with the contribution of recruitment estimates to the likelihood function used by the ASAP assessment model was also resolved.

The retrospective pattern for spawning stock biomass, measured as the relative difference between estimates using the full time series of data and subsequent runs using less data, was characterized by all “peels” suggesting overestimation, and average Mohn’s rho equaled 0.66 (Figure 9).

Empirical estimates of total consumption and the consumption predicted from natural mortality rates used in the stock assessment no longer match for much of the time series as they did in NEFSC (2012; Figure 10). The levels of consumption that would result from the input natural mortality rates in the stock assessment are generally higher than the estimates of total consumption estimated from diet data, and trends diverge in recent years (Figure 10). Thus, the 50% increase in natural mortality from 1996-2014 no longer resolves the retrospective pattern and justification for incorporating time varying natural mortality in this way has weakened.

Given the divergence in recent years between the empirical estimates of consumption and consumption predicted from the stock assessment fit, the same model as above was fit except with natural mortality during 2009-2014 reduced by 30% from the base levels (i.e., estimated using a combination of methods from Lorenzen (1996) and Hoenig (1983)) to better match the empirical estimates. This process of changing natural mortality to approximate the scale and trend in the empirical estimates was consistent with methods used in the 2012 assessment. Natural mortality in all other years was the same as described above, as were all other model specifications.

The retrospective pattern for spawning stock biomass, measured as the relative difference between estimates using the full time series of data and subsequent runs using less data, was characterized by all “peels” suggesting overestimation, and average Mohn’s rho equaled 1.91 (Figure 11).

Empirical estimates of total consumption and the consumption predicted from natural mortality rates used in the stock assessment approximately match as they did in NEFSC (2012), and estimates in recent years were also relatively consistent (Figure 12). Despite this consistency, the method of changing natural mortality in the stock assessment to match the scale and trend of empirical consumption estimates worsens the retrospective pattern and degrades model performance in this case.

Conclusions

Survey and catch age compositions updated through 2014 suggest that the 2008 cohort was relatively large, which is consistent with the conclusions of NEFSC (2012). This cohort has comprised the majority of fishery catches in recent years. This cohort, however, in the 2015-16 fishery will be 7-8 years old and may no longer contribute as much to the fishery as in recent years.

Survey and catch age compositions also suggest that the 2011 cohort is average or better and has become a significant contributor to fishery catches. The size of the 2011 cohort, however, should be considered uncertain because only a few survey data points are available and it is at an age that is not yet fully selected by the mobile gear fishery.

The relatively large 2008 cohort and the average or better 2011 cohort suggest that catches in the range observed from 1994-2013 have not led to recruitment overfishing. Survey indices in recent years have also been near long-term averages and relative fishing mortality rates have generally been low in recent years (see above), which suggests that recent catches have not been destabilizing. Thus, using average of recent catches may be a reasonable starting point from which to base catch advice in the absence of a stock assessment.

Recent Catches – Advice

The average total catch of the herring stock (US catches and Canadian catches in the Bay of Fundy) from 1985-2014 equaled 105,200mt. Greater than 80% of the catch each year during this period was attributable to the mobile gear fishery, and so the mean catch during 1985-2014 is consistent with recent fishery conditions in that regard. The mean catch from 1985-2014, however, is affected by some low values early in the time series when the herring stock was likely at low abundance, and some high values in the 1990s that were premised on a stock assessment that was likely too optimistic (Figure 13). Consequently, the mean catch from 1985-2014 may poorly represent recent conditions and may be inappropriate to serve as an overfishing or annual catch limit. Total catches from 1994-2014 were relatively stable (see above), and average total catches during this time period may be more representative of recent average conditions. Average total catch from 1995-2014 equaled 112,000mt, and the average from 2005-2014 equaled 98,500mt.

Figure 1. NMFS spring, fall, and summer shrimp bottom trawl survey indices for Atlantic herring (plus/minus 1 standard deviation). The horizontal dashed line is the average value from 1985-2014 for each survey.

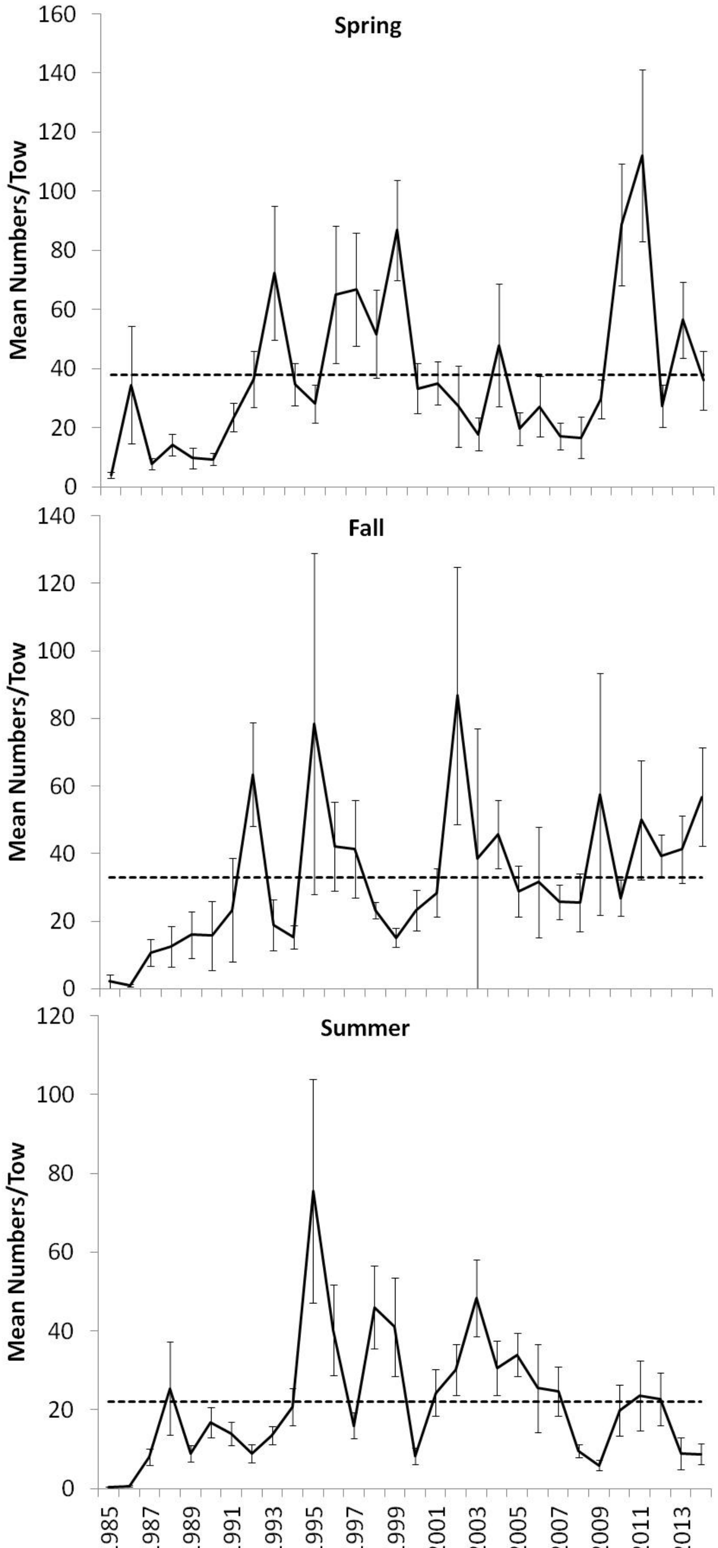
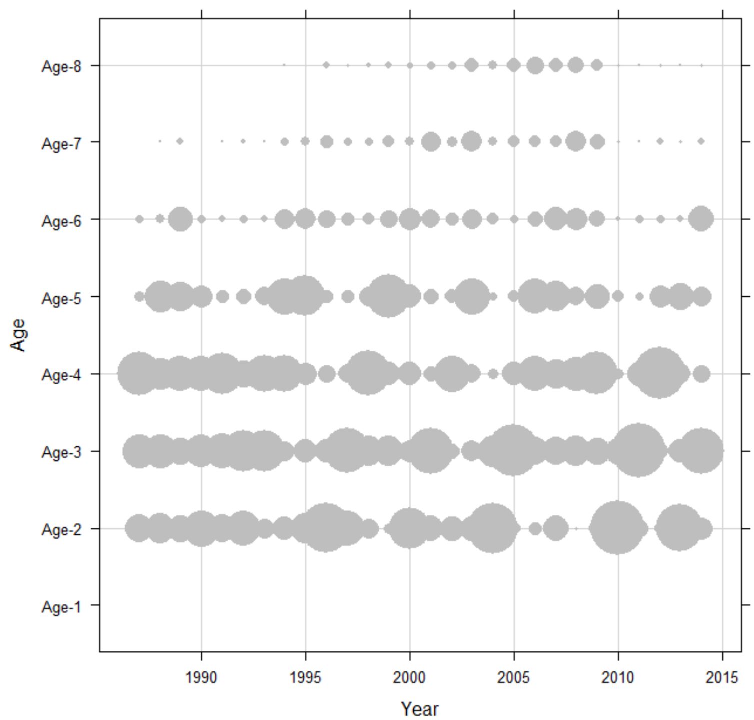


Figure 2. NMFS spring and fall bottom trawl survey age compositions for Atlantic herring expressed as annual proportions (i.e., values-at-age for each year sum to 1.0).

Spring Survey Age Comp (annual proportions)



Fall Survey Age Comp (annual proportions)

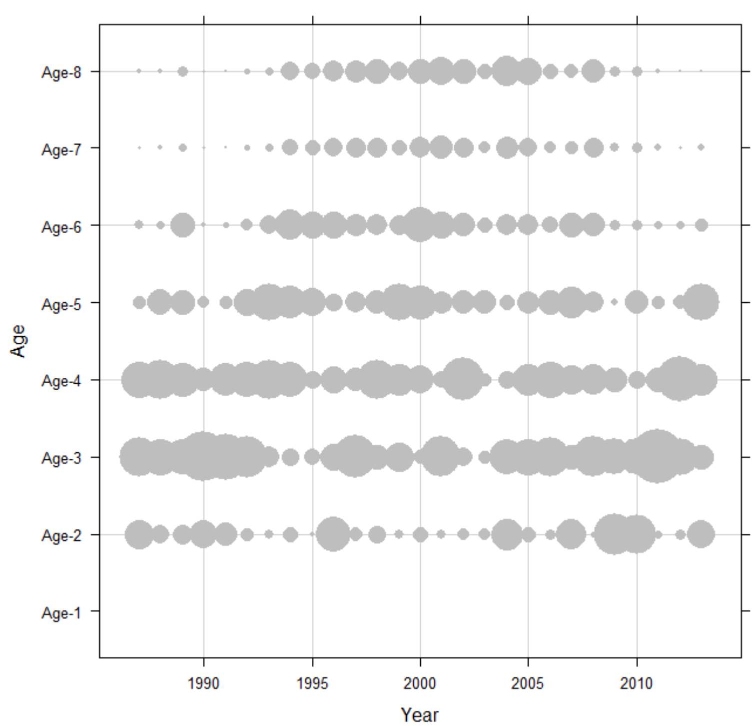


Figure 3. Total Atlantic herring catch (US mobile + US fixed + Canadian weir).

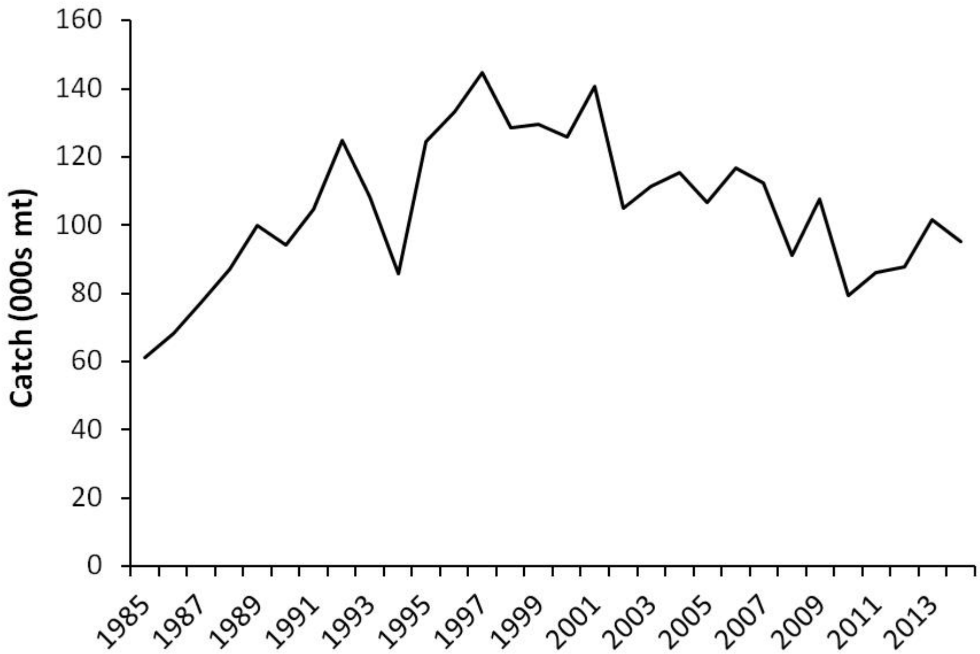
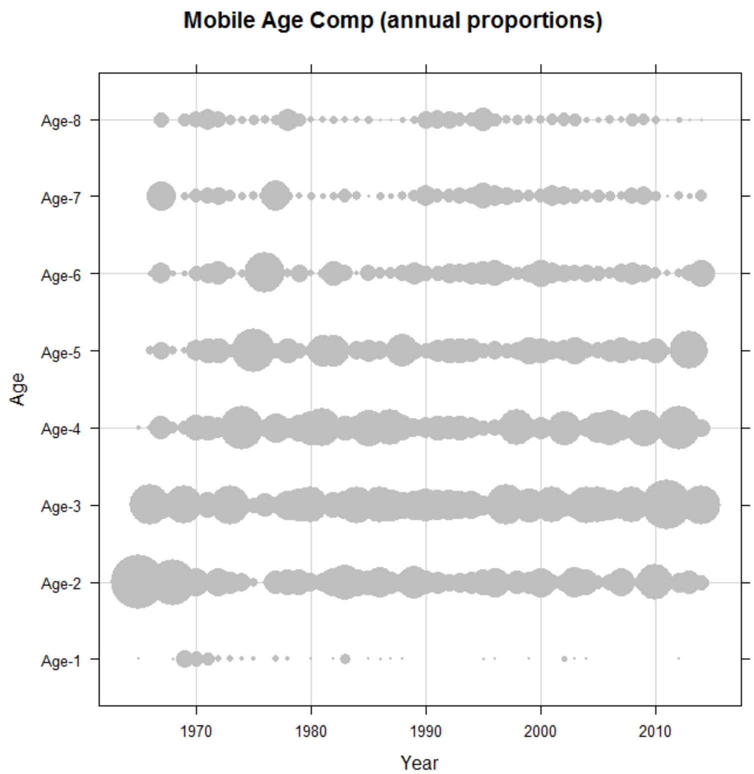


Figure 4. Mobile and fixed gear fishery age compositions for Atlantic herring.



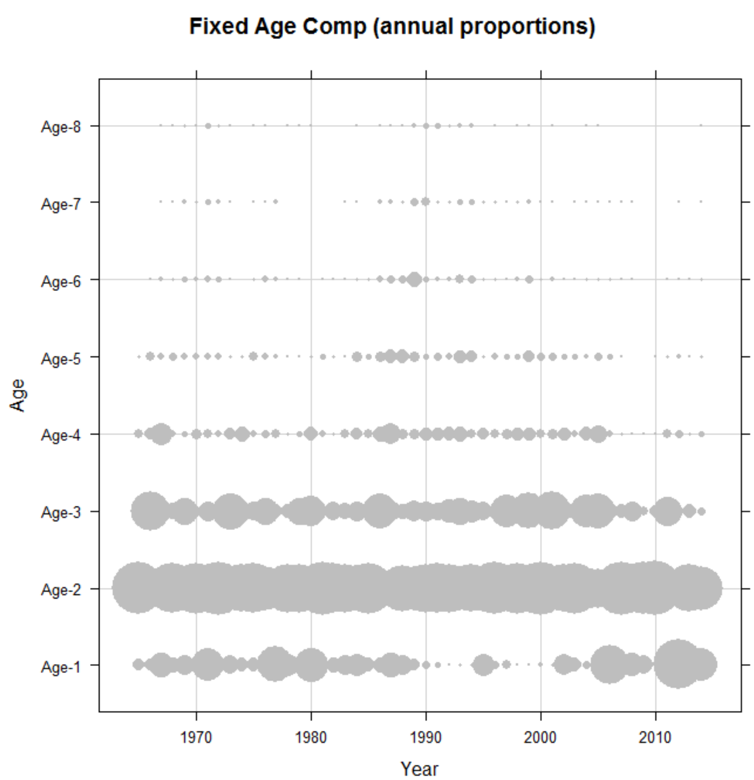


Figure 5. Relative fishing mortality based on total catch and survey biomass for the NMFS spring (top panel), fall (middle panel), and summer shrimp (bottom panel) surveys.

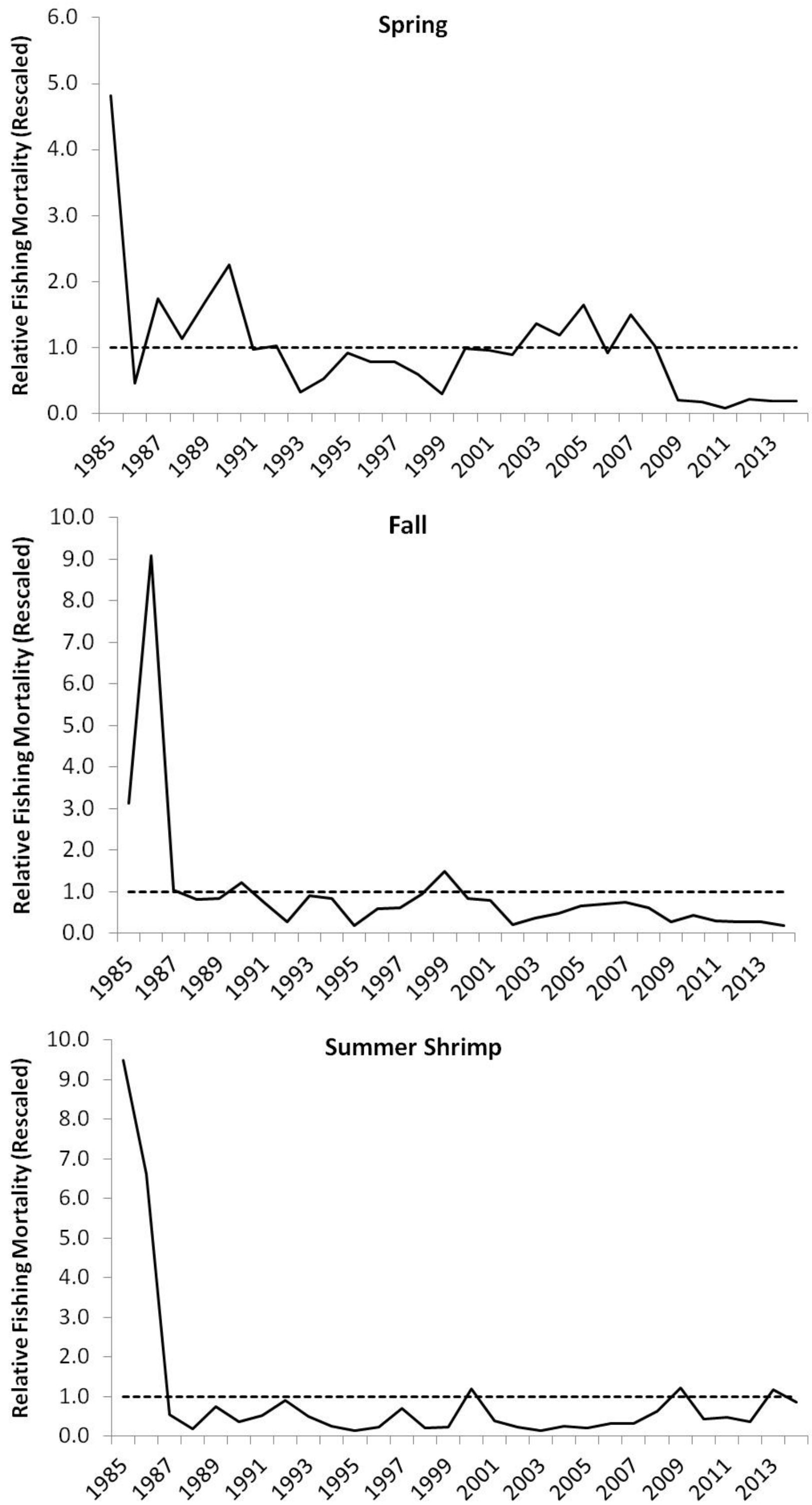


Figure 6. Relative fishing mortality rates by age for the NMFS spring survey (note range of years differs from Figure 5 due to availability of age data beginning in 1987).

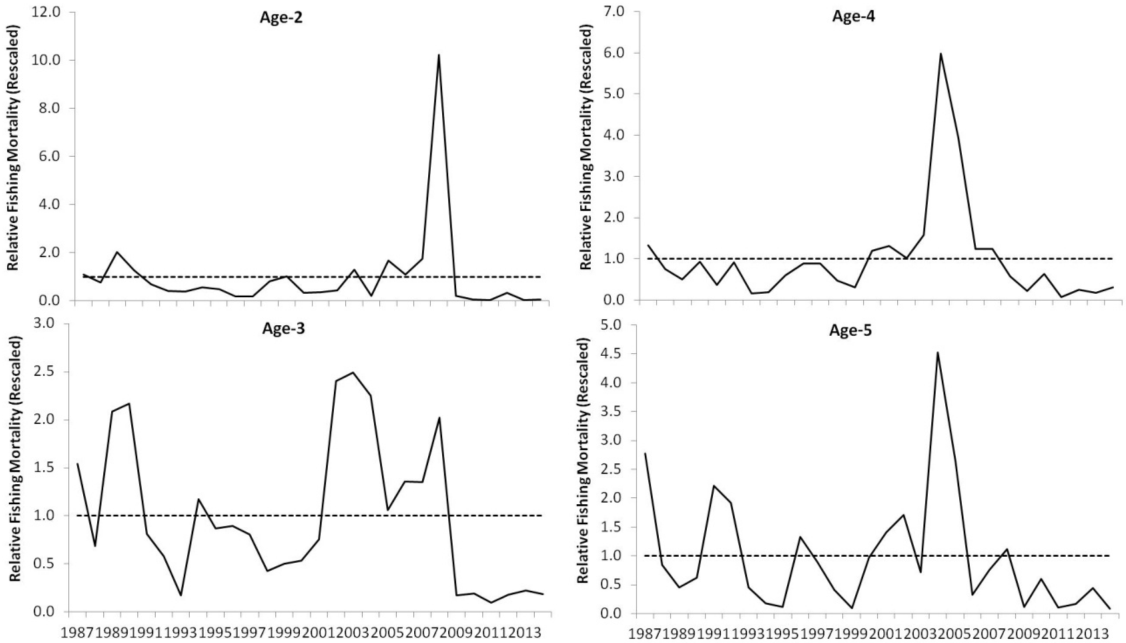


Figure 7. Relative fishing mortality rates by age for the NMFS fall survey (note range of years differs from Figure 5 due to availability of age data beginning in 1987).

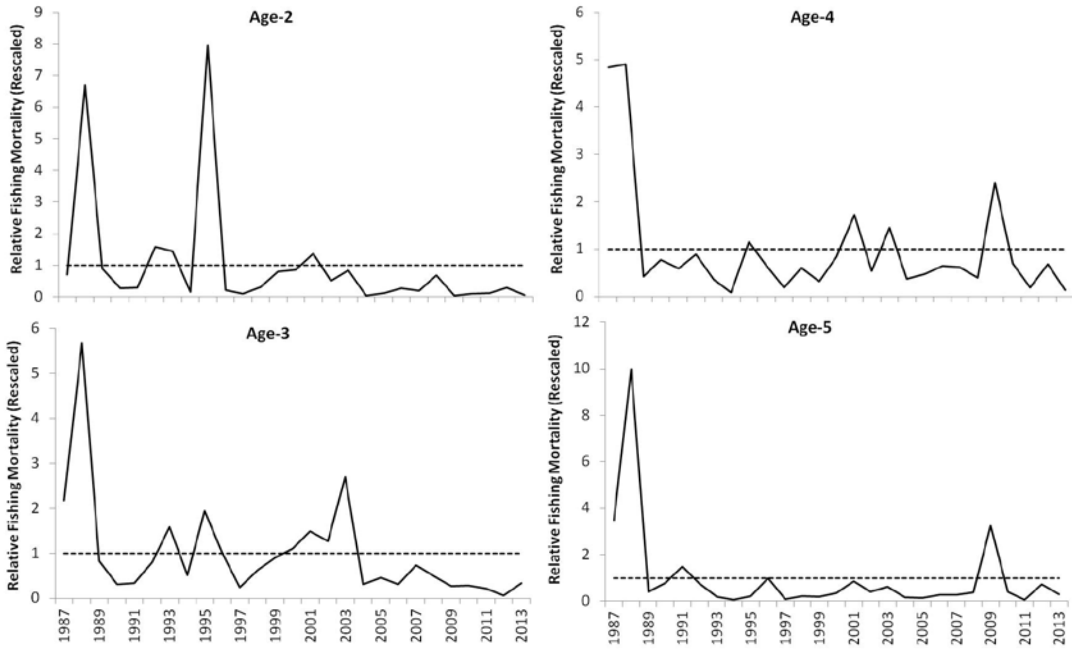


Figure 8. Total empirical consumption estimates of Atlantic herring. The horizontal dashed line is the average consumption from 1985-2013.

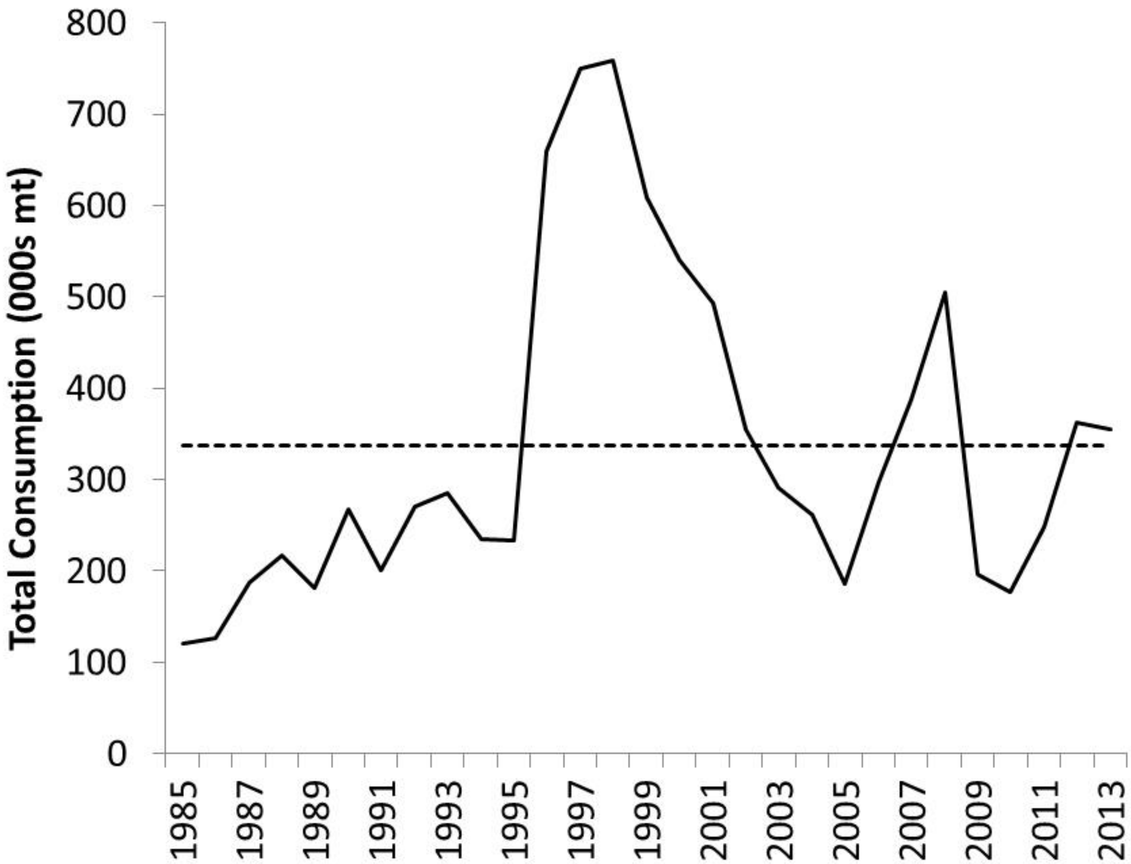


Figure 9. Retrospective pattern for spawning stock biomass resulting from updating the 2012 Atlantic herring stock assessment using data through 2014.

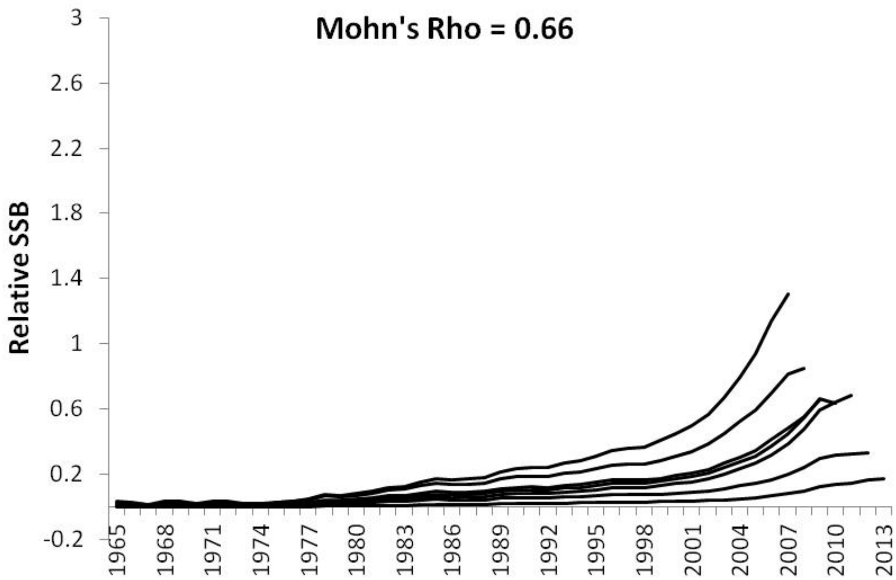


Figure 10. Total consumption of Atlantic herring by predators (solid black; Fish+Other) and the consumption of herring that would result based on input natural mortality rates in the updated stock assessment equivalent to the previous assessment.

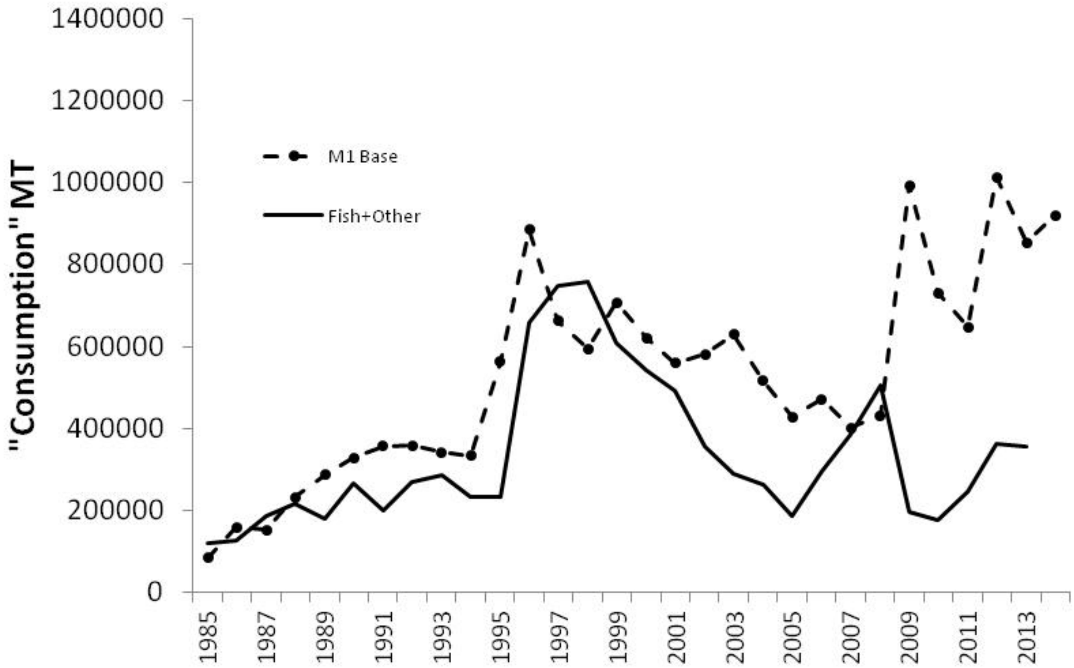


Figure 11. Retrospective pattern for spawning stock biomass resulting from updating the 2012 Atlantic herring stock assessment using data through 2014 and changing natural mortality from 2009-2014 to match empirical estimates of consumption.

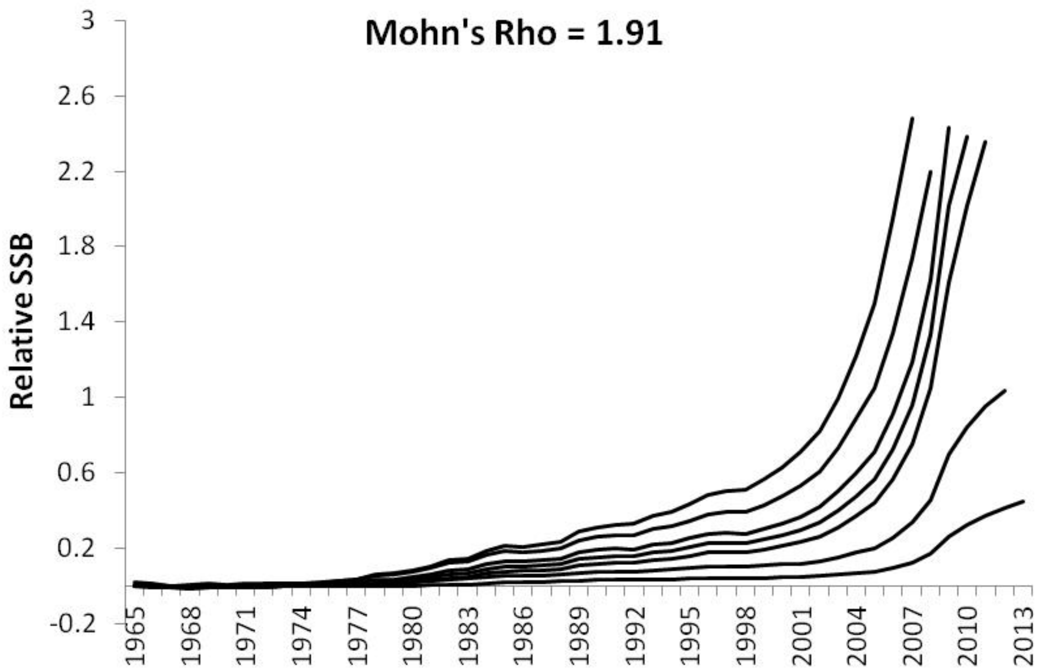


Figure 12. Total consumption of Atlantic herring by predators (solid black; Fish+Other) and the consumption of herring that would result based on input natural mortality rates in the updated stock assessment with natural mortality rates increased from a base from 1996-2008 and decreased from a base from 2009-2014.

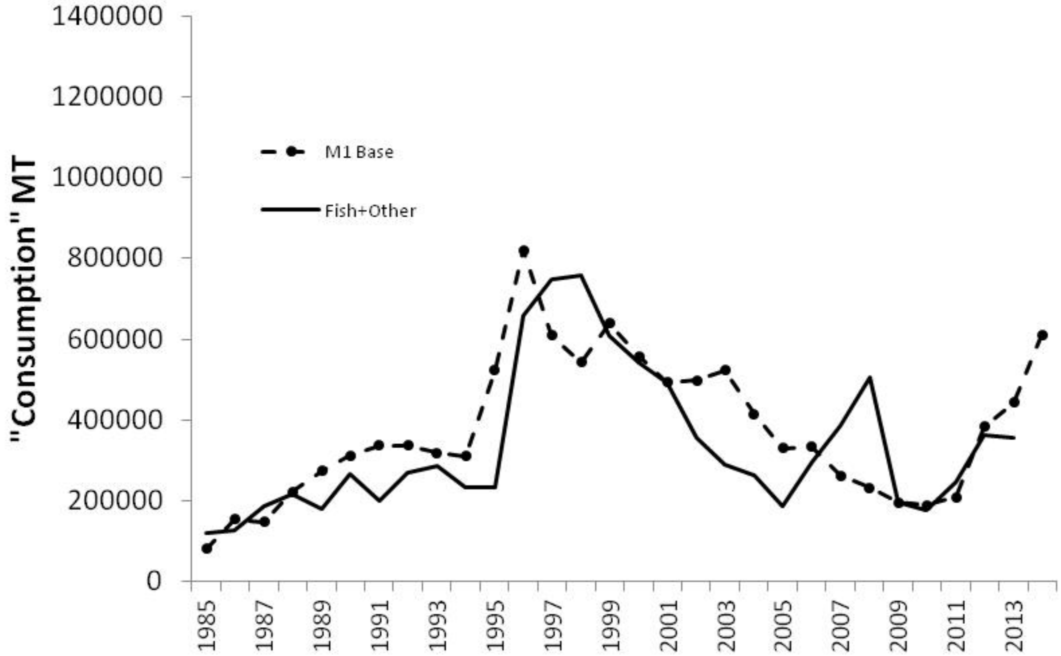


Figure 13. Historic retrospective pattern as reported in NEFSC (2012).