2021 Atlantic mackerel management track assessment

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NEFSC, Stock assessment lead
July 2021
NW Atlantic mackerel seasonal migration patterns
(Sette 1950)

Spring Migration

Fall Migration
Background

- Last assessed and reviewed in November 2017 (SAW 64)
- Primary assessment model = ASAP (supporting models: censored catch & SAM)
  - Ages 1-10\(^+\); Constant M = 0.2
  - One fishing fleet, time-invariant flat-topped selectivity (age 6\(^+\) = 1)
  - Three fishery-independent surveys
    - Range-wide SSB index from egg surveys
    - Spring bottom trawl survey (ages 3\(^+\), dome-shaped selectivity)
      - Albatross years (1974-2008)
      - Bigelow years (2009\(^+\))
    - Projections based on empirical CDF derived using recruitment estimates from 1975 onward
  - BRPs: F40\% as Fmsy proxy (0.26)
- Resulting stock status: overfished (22.1\% of SSB msy proxy) with overfishing occurring (180\% of Fmsy proxy)
  - Frebuild = 0.237 (F to rebuild stock in five years)
Term of Reference 1:
Estimate catch from all sources, including landings and discards
Total catch (thousands mt)

Reported Canadian catches represent a subset of total Canadian catch because the bait fishery, recreational fishery and commercial discards are not monitored.
U.S. catch (thousands mt)

Year

Catch (thousands mt)
0 10 20 30 40

Comm landings
Comm discards
Recreational catch

[Bar chart showing the catch in thousands of metric tons from 1992 to 2017 for commercial landings, commercial discards, and recreational catch.]
U.S. recreational catch: Recalibrated MRIP estimates
Updated total catch estimates
Total catch-at-age (U.S. plus Canada)

Min=0.001  Mean=29.579  Max=572.914
Term of Reference 2:
Evaluate indices used in the assessment
NEFSC spring survey: *Bigelow years*

- **Number-per-tow**
  - **Year**: 2010, 2012, 2014, 2016, 2018
  - **Number**:
    - Min: 0.002
    - Mean: 1.027
    - Max: 9.409

- **Weight-per-tow**
  - **Weight**:
    - Min: 0.002
    - Mean: 1.027
    - Max: 9.409
Combined range-wide SSB index (egg and ecosystem surveys)
Contribution of the southern spawning contingent

![Graph showing contribution of the southern spawning contingent over years from 1980 to 2020. The x-axis represents the year, and the y-axis represents the proportion. The data points are scattered across the graph, showing variability in contribution over the years.]
Term of Reference 3:
Estimate annual fishing mortality, recruitment and stock biomass for the time series using the approved assessment method and estimate their uncertainty. Include retrospective analyses if possible (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit.

Include bridge runs from the previously accepted model to the updated model proposed for this peer review.
ASAP estimates:

Spawning stock biomass (mt)

Recruitment (000s)
ASAP estimates:

R/SSB
ASAP estimates:
Fishing mortality
Bridge runs:

1) Revise fishery catch (MRIP, Canadian catch), CAA and WAA

2) Revise U.S. egg indices
Retrospective analysis: 5 year peels 2014-2018

2017 benchmark
Mohns ρ estimates:
F = 0.112
SSB = 0.162
Rect = -0.074

ρ = -0.093

ρ = 0.326

ρ = 0.431
Natural mortality

![Graph showing the relationship between natural mortality and likelihood difference.](attachment:graph.png)
Historical retrospective

* 2009 TRAC did not pass peer review
Historical retrospective
Term of Reference 4:
Re-estimate or updated the BRP’s as defined by the management track level and recommend stock status. Provide qualitative descriptions of stock status based on simple indicators/metrics.
## Biological reference points

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<th>2017 Bench.</th>
<th>2021 MT</th>
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<td>196,894</td>
<td>181,090 (102,292-386,653)</td>
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<td>$B_{\text{MSY proxy}}$</td>
<td>255,646</td>
<td>237,989 (134,641-486,985)</td>
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<td>MSY proxy</td>
<td>41,334</td>
<td>34,103 (19,404-70,927)</td>
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Recommended stock status

Overfished (23.7% of SSB msy proxy) with overfishing occurring (208% of Fmsy proxy)

2019 estimates:
F: 0.46  
(0.25-0.87)
SSB: 42,862  
(24,371-75,844)

0.5*SSB_{40\%} = 0.5*SSB_{MSY Proxy} = 90,545 mt
SSB_{40\%} = SSB_{MSY Proxy} = 181,090 mt

F_{40\%} = F_{MSY Proxy} = 0.22
Qualitative stock status metrics

- Age truncation apparent in fishery catches
  - Age-9 fish were observed in 2019 fishery catch for the first time since 2012
- Range-wide SSB estimates from egg surveys have been below the time-series median since 2005
  - Southern contingent egg production was an order of magnitude greater in 2018-2019 compared to the previous decade
- With the exception of the 2015 year class, recruitment estimates have been below the time-series median since 2008
- 2016 year class was the smallest estimate of the time series
2021 Canadian assessment of the northern contingent

- In 2020, SSB was estimated to be 27,599 mt and 23.4% of the SSB msy proxy
- SSB has been in the critical zone since 2011.
- Fully selected fishing mortality was estimated to be 1.30 in 2020 and has been above F40% since 1998
- The 2015 year class was the only year class estimated to be greater than the time-series median since 2009, with this cohort now representing less than 8% of the harvested catch in 2020
Term of Reference 5:
Conduct short-term projections
Short-term projections

- Following approved methodology, recruitment sampled from an empirical CDF derived using recruitment estimates from 1975 through the terminal year
  - Sensitivity analyses: empirical CDF based on recruitment estimates from 1999 onward and 2009 onward
- Interim catch assumptions
  - 2020: Preliminary US & Canadian catch estimates (18,038 mt)
  - 2021: Sum of U.S. and Canadian ABCs (23,184 mt)
- Canadian assessment:
  - Biological reference points were derived using the full recruitment time series estimated in the model (1968-2020)
  - Short-term projections were derived using 1) the full recruitment time series and 2) the mean recruitment over the last decade
2-year projections, Fmsy
SSB (mt)

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<th>1999 Onward</th>
<th>2009 Onward</th>
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SSB_{MSY PROXY} = SSB_{40%} = 181,090 mt
Comparison with 2017 benchmark projections

SSB_{MSY, PROXY} = SSB_{40\%} = 181,090 mt

ASAP estimates:
- 2017 Benchmark
- 2021 MT

Projections:
- 2017 Benchmark (Frebuild, 0.237)
- 2021 MT (Fmsy, 0.22)
Comparison with 2017 benchmark projections

- 2017 Benchmark
- Updated removals, recent recruitment
- Updated removals, maturity and WAA
- Updated removals, retro adjusted
- 2021 Management Track, recent recruitment

2017 Benchmark terminal year
2021 Management track terminal year
10-year projections for SSC

- Recruitment assumptions: 1975 onward and 2009 onward
- Constant catch scenarios: 7,500mt, 14,185 mt, 18,149 mt
- 25%, 50%, 75%, 90% and 100% of Fmsy to provide idea of rebuilding timelines
- P*: 100% and 150% CV using BRPs derived using recruitment estimates from 1975 onward
Constant catch

- 7,500 mt
- 14,185 mt
- 18,149 mt

Rect assumption:
- SSBmsy (181,090 mt)

1975 onward

2009 onward
### Rebuilding timelines (bracketed using proportion of MSY)

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<td>90%</td>
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Year rebuilt or SSB in 2032
**P*: 100%CV, Recruitment 1975 onward

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<td>13465</td>
<td>23,661</td>
<td>13465</td>
<td>0.302</td>
<td>0.12</td>
<td>127891</td>
<td>0.71</td>
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<td>2032</td>
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<td>23,716</td>
<td>13552</td>
<td>0.303</td>
<td>0.12</td>
<td>128100</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Questions?

E. Svensen
Recent 5-year averages for 2021 MT and 2017 Benchmark

Age-3 = 0.94 (0.996)
Age-2 = 0.71 (0.88)
Age-1 = 0.18 (0.17)
SSB Weight-at-age

Recent 5-year averages for 2021 MT and 2017 Benchmark

Age-8: 0.61 (0.67)
Age-7: 0.55 (0.64)
Age-6: 0.52 (0.59)
Age-5: 0.48 (0.55)
Age-4: 0.40 (0.47)
NEFSC spring survey: *Albatross years*

- **Number-per-tow**
  - Min=0.002
  - Mean=0.837
  - Max=16.165

- **Weight-per-tow**
  - Min=0.002
  - Mean=0.837
  - Max=16.165

- **Age**
  - Year
  - Median number
  - Median weight

Graph shows variations in number and weight per tow over different years (1970-2000) and ages (3-10).
ASAP diagnostics: Fit to fishery catch
ASAP diagnostics: Index RMSEs

![Root Mean Square Error for Indices](image)

- **index sel.params**
- **Ind.total**
- **Spring Alb 3+**
- **Spring Big 3+**
- **Combined SSB**
ASAP diagnostics: Fit to range-wide SSB index
ASAP diagnostics: Fit to *Bigelow* index (2009-2019)
ASAP diagnostics: Fit to Albatross index (1968-2008)
ASAP estimates: SSB and recruitment time series
ASAP estimates: Biomass
ASAP estimates:
Fishing mortality
ASAP estimates: Selectivity
ASAP estimates: Terminal year estimates
Retrospective analysis:
Terminal year estimates with 90% CIs
Fishery selectivity
Long-term projections

- 100-year projections at $F_{40\%}$ (0.22) from 2000 numbers-at-age estimates for 2019 from MCMC simulations
- Recent 5-year averages used for weight-at-age and proportion mature-at-age estimates
- Age-specific fishery selectivity estimates from ASAP model
- Recruitment sampled from an empirical CDF derived from 1975-2019 recruitment estimates of the final ASAP model
- $M = 0.2$
**2-year projections: F=0**

**SSB (mt)**

<table>
<thead>
<tr>
<th>Year</th>
<th>1975 Onward</th>
<th>1999 Onward</th>
<th>2009 Onward</th>
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<tbody>
<tr>
<td>2020</td>
<td>62,039</td>
<td>62,039</td>
<td>60,343</td>
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<tr>
<td>2021</td>
<td>70,137</td>
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<td>124,505</td>
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