NOAA FISHERIES

Southeast Fisheries Science Center

Atlantic menhaden stock assessment

Tuesday, February 3, 2015

Atlantic Menhaden Management Board meeting

Outline

- Terms of reference
- Data used
- Stock assessment
- Major changes from last assessment
- Reference points
- Future directions

Terms of reference

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1. Review and vet all available data sources.
2. Characterize precision and accuracy of data.
3. Develop population assessment models compatible with data. Analyze performance.
4. Characterize uncertainty.
5. Perform retrospective analyses.
6. Recommend stock status. Recommend alternative reference points, if appropriate.

Terms of reference

7. Identify potential ecological reference points that account for Atlantic menhaden's role as a forage fish. (Jason McNamee's presentation)
8. Research recommendations.
9. Recommend timing of next assessment.

TOR 1: Data used

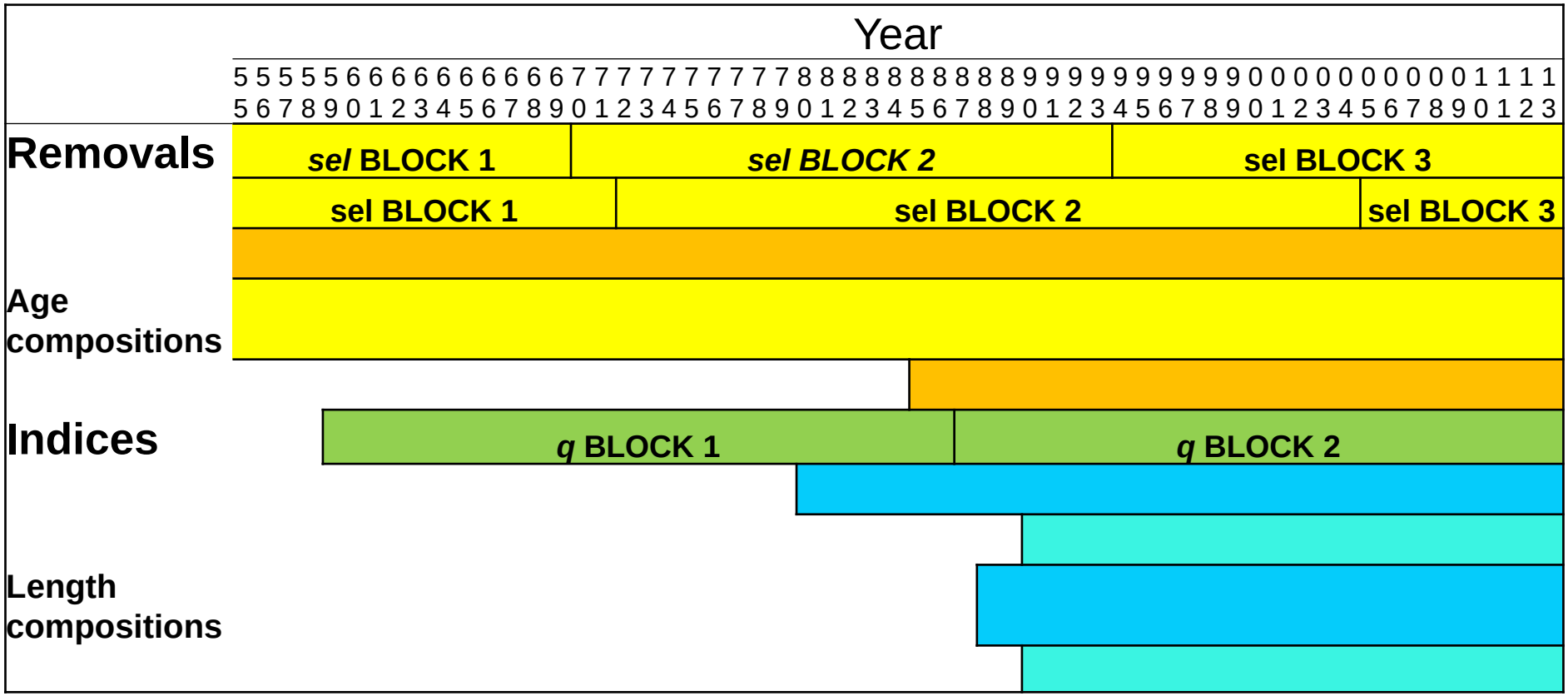
Data used

- Life history data
  - Maturity: historical data
  - Natural mortality: age-varying, time constant values; scaled to estimates from the tagging data
  - Growth: estimated from fishery-dependent data

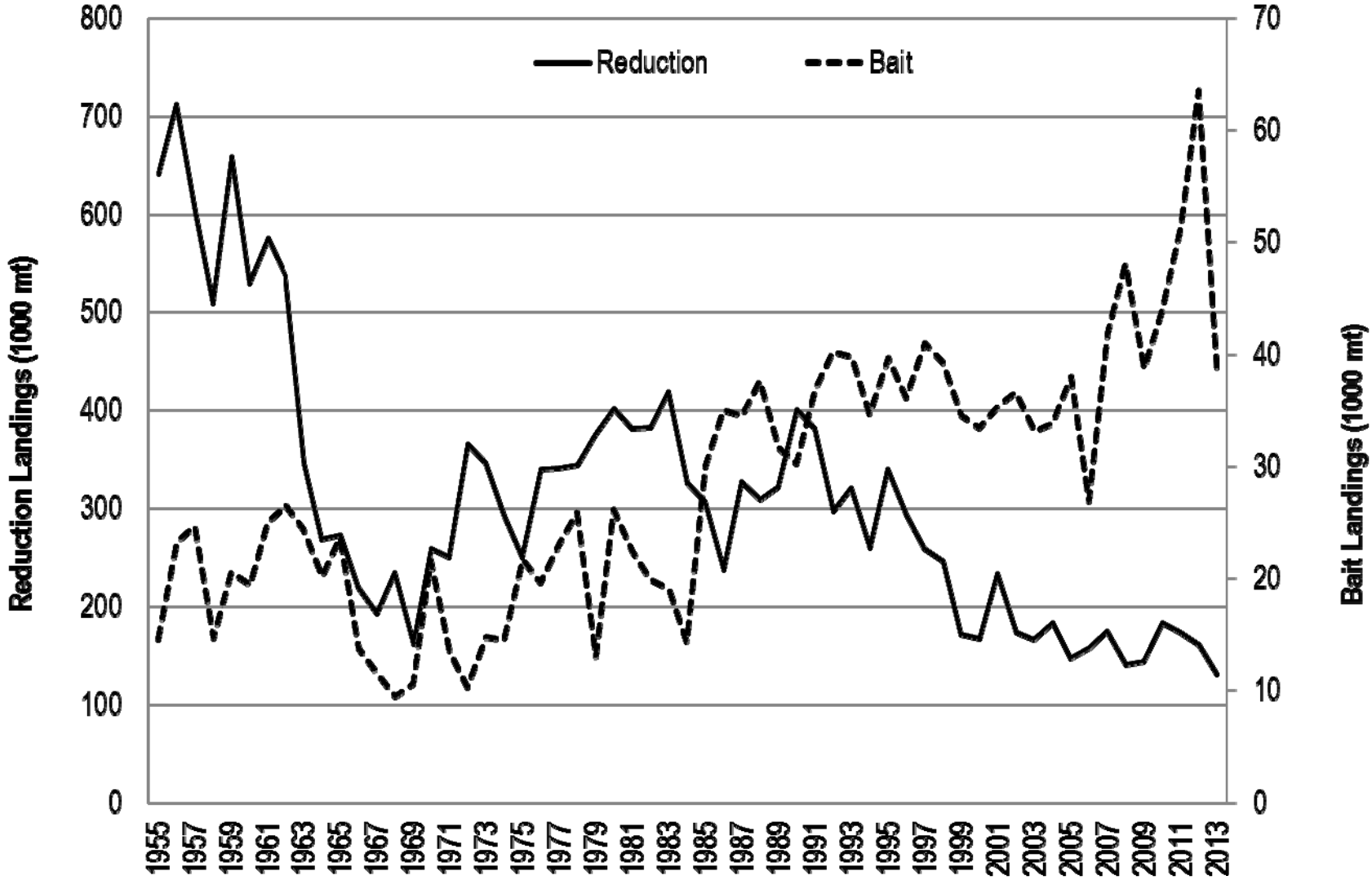
Data used

Yellow = Reduction fishery
Orange = Bait fishery

Green = Recruitment index
Dark blue = Northern adult index
Light blue = Southern adult index



- Selectivity blocks: fishery changes and migrations


Reduction
Bait
Reduction Landings (1000 mt)
Bait Landings (1000 mt)
800
700
600
500
400
300
200
100
0
70
60
50
40
30
20
10
0
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013

Data used

- ~40 fishery-independent surveys considered
  - Not designed to sample menhaden, but useful for menhaden (and potentially other assessments)
- Needed to meet criteria to be further considered
- Datasets were used to create standardized indices
  - Accounts for catchability differences due to factors such as time of year or environment
- 3 indices of relative abundance: YOY index, northern adult index, and southern adult index

TOR 2: Precision and accuracy of data

Precision and accuracy of data

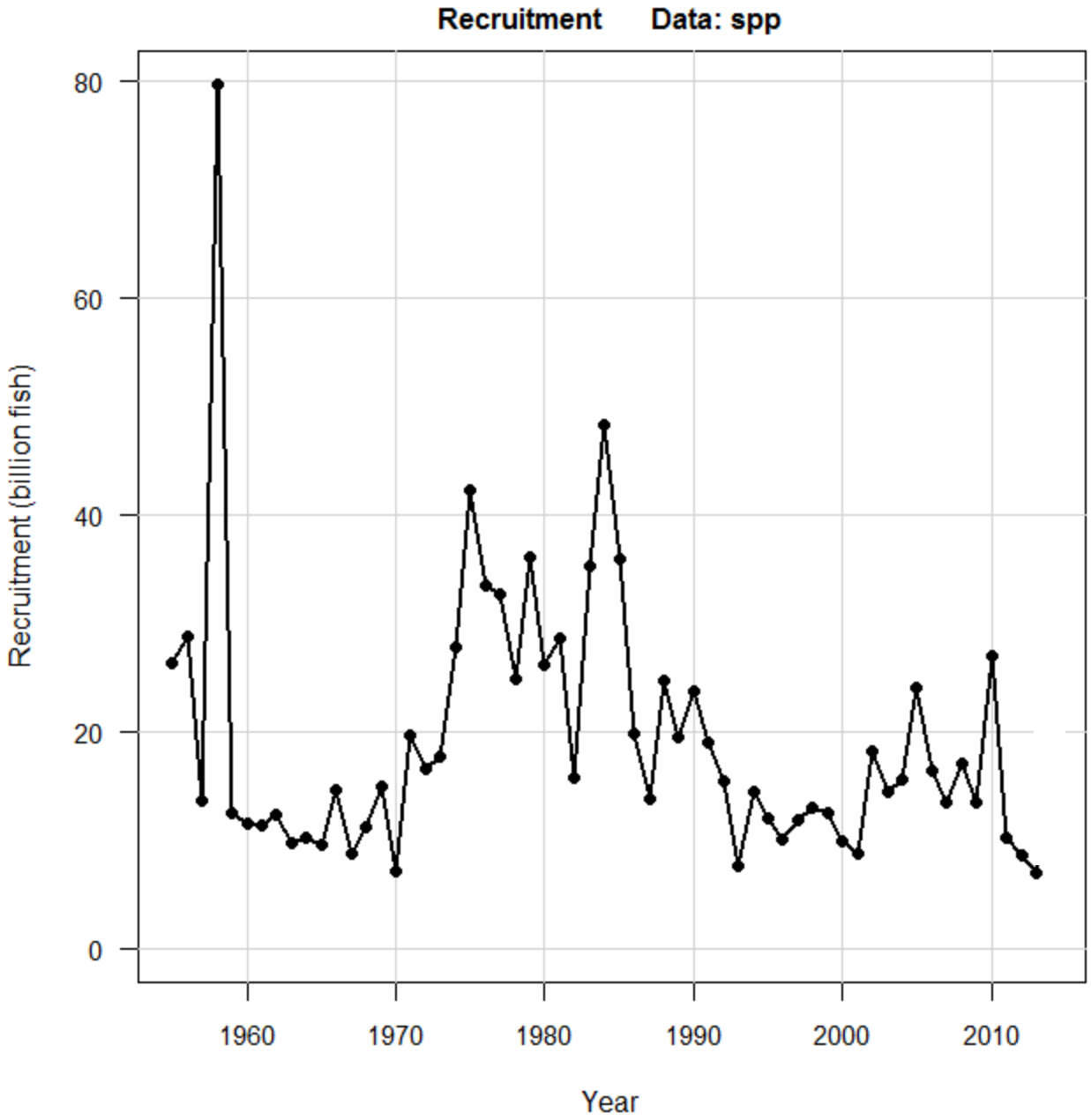
- Uncertainty around data was included
  - E.g., annual uncertainty for landings (e.g., measuring, reporting) and indices
- Comparisons among indices supported accuracy of the data
  - E.g., northern adult index and southern adult index were correlated or showed same general patterns over time

TOR 3: Stock assessment

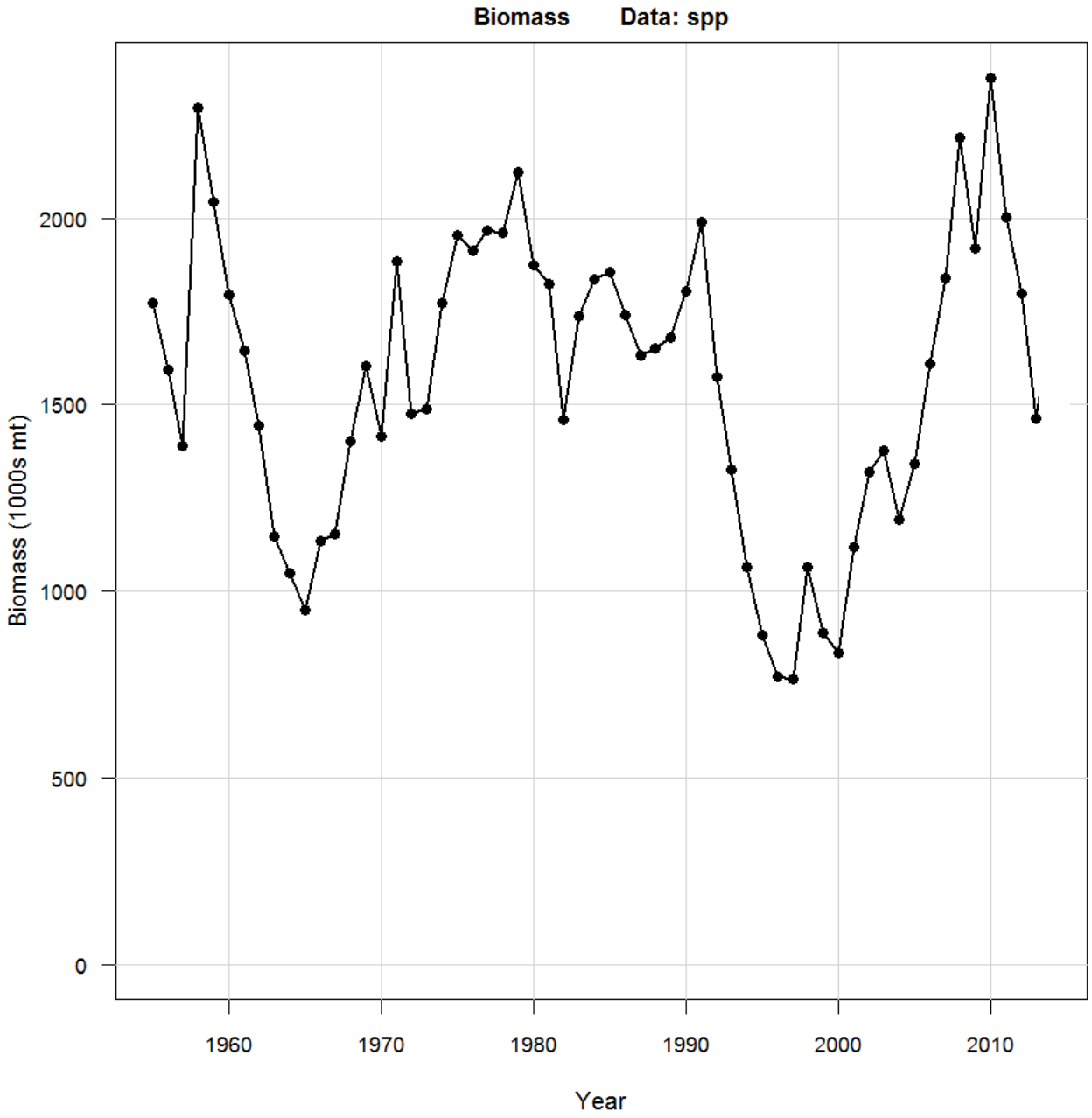
Base run information

- Data were split into northern and southern regions
  - Migration, fishery dynamics, tagging data
  - Better accounts for population dynamics and fishery removals over time
- Using run recommended by SEDAR Review Panel
  - Same as base run in report except length composition information down weighted
  - Allows length information to inform selectivity of the indices, but not other model outputs

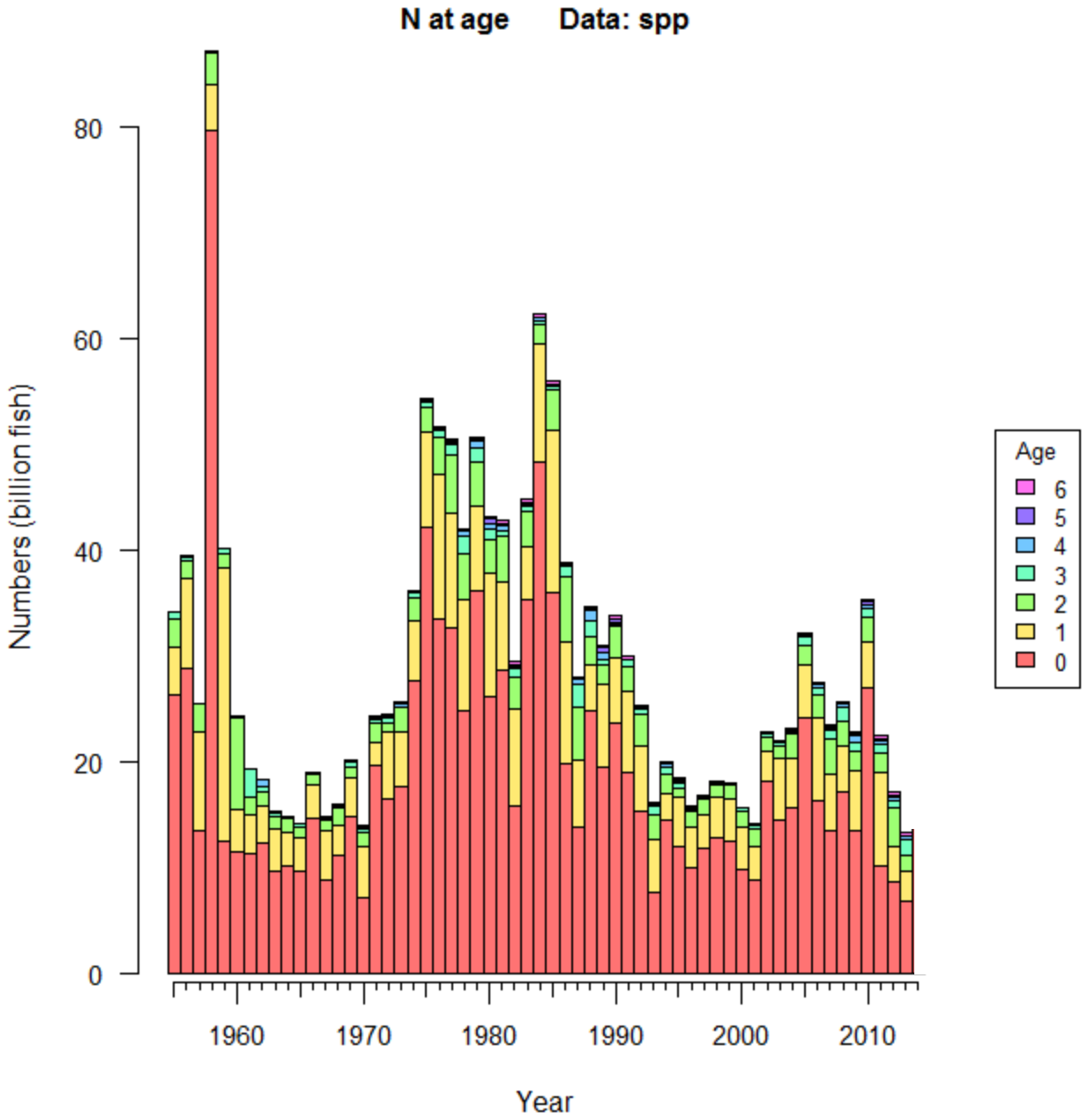
Recruitment



Biomass


Biomass Data: spp
Biomass (1000s mt)
2000
1500
1000
500
0
1960
1970
1980
1990
2000
2010
Year

Abundance


N at age Data: spp
Numbers (billion fish)
0
20
40
60
80
1960
1970
1980
1990
2000
2010
Year
Age
6
5
4
3
2
1
0

TOR 4: Characterize uncertainty

Characterize uncertainty

- Sensitivity runs
  - Not considered alternate states of nature
  - Used to assess impact of assumptions made in the model
    - E.g., fishery selectivities – a run with selectivity for each fishery as flat topped or asymptotic
    - E.g., inclusion of indices
  - Stock status robust to model assumptions = stock status was same as base run

Characterize uncertainty

- Monte Carlo bootstrapping (MCB)
  - Accounted for uncertainty in the data and model assumptions such as natural mortality
  - Stock status was same as base run

TOR 5: Retrospective analysis

Retrospective analysis

- Was run back to 2009
- No general statement about fishing mortality rate
  - Pattern dependent upon age
  - F at age-2 – no general pattern
  - F at age 3 – under predicting ~12%
- Under predicting recruitment ~30%
- Over predicting fecundity ~12%

Major changes from last assessment

Major changes from last assessment

- Historical maturity data and interpretation of past maturity paper
  - Maturation occurring younger
  - Accounting for changes in maturity over time
- Natural mortality is time constant but age varying
  - Includes mortality due to disease, predation, environment, senescence, etc
  - Estimates are similar to MSVPA values
  - Sensitivity run

Major changes from last assessment

- Two new fishery-independent indices of relative adult abundance
  - Information on relative changes in abundance over time across a broader spatial scale
  - Uses state survey data
- Updated YOY or recruitment index of relative abundance
  - Includes more gears and states

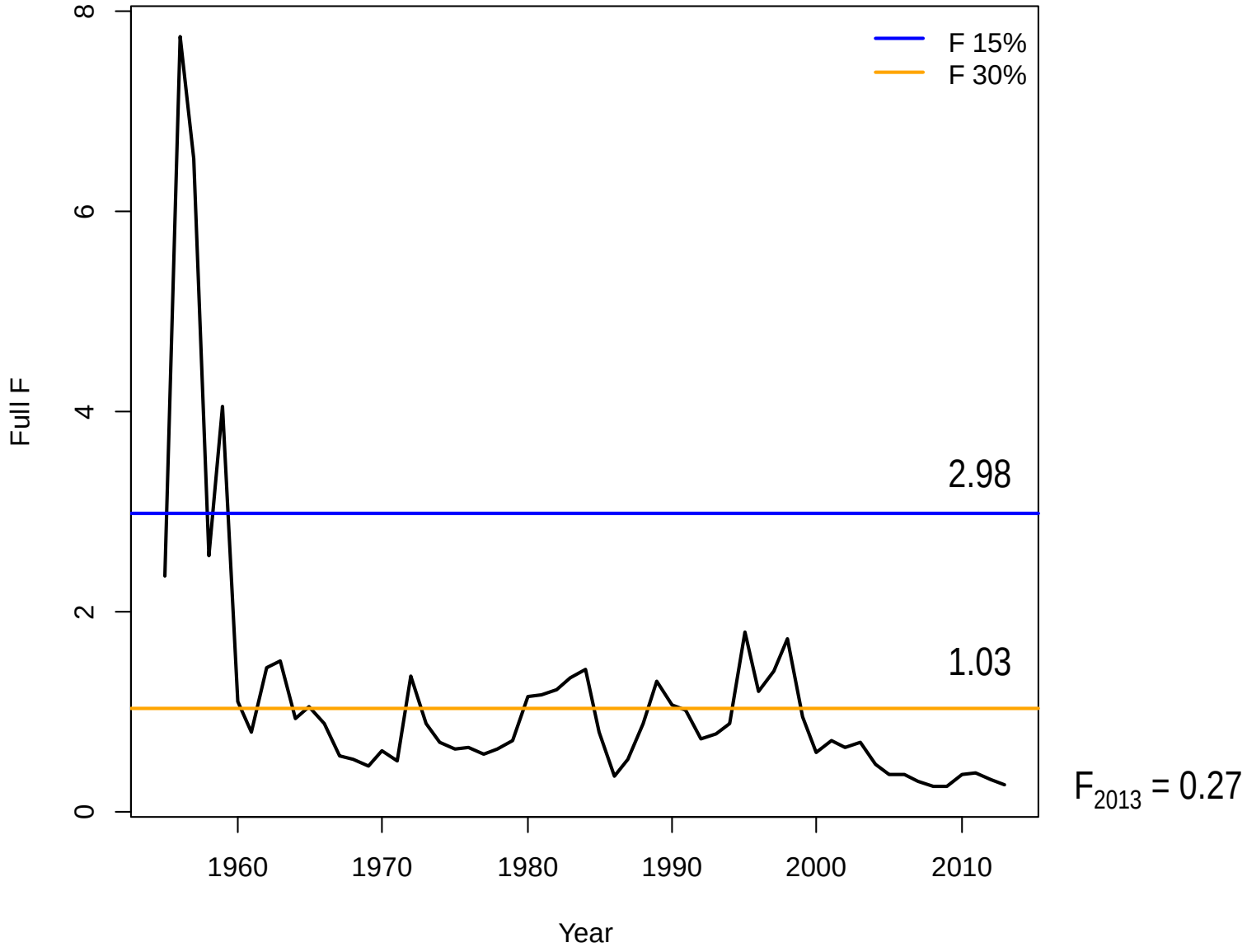
Major changes from last assessment

- Model separated into northern and southern fleets
  - Based on migratory patterns of the species
  - VA eastern shore
- Fishery selectivity dome-shaped
  - Data supported (i.e., large fish captured in fishery-independent survey gear)
  - Time varying based on changes in plant operation over time

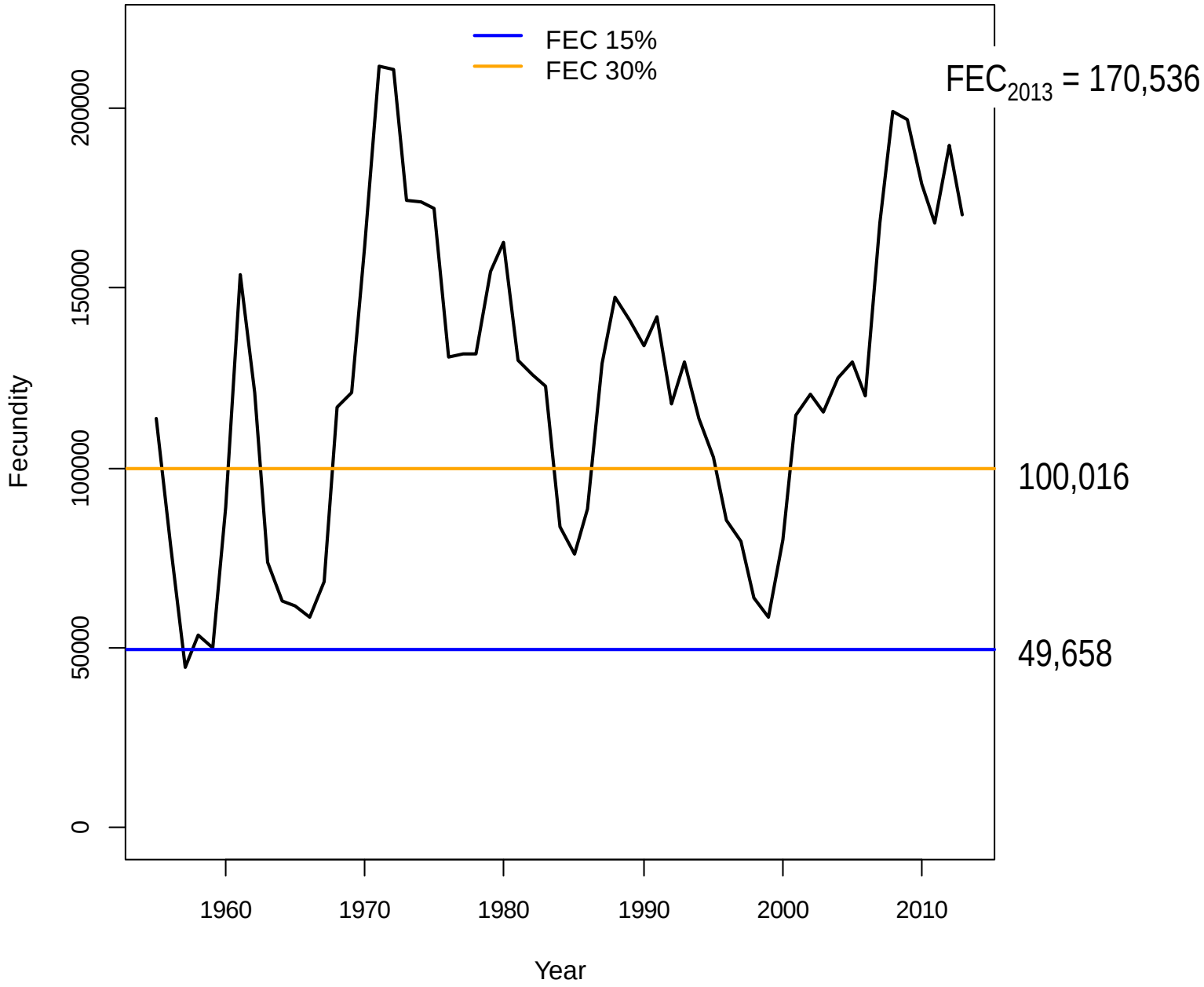
TOR 6: Reference points

Reference points

- Currently, using Board selected
  - Threshold = 15% MSP (max spawning potential)
  - Target = 30% MSP
  - Chosen based on 2010 assessment when stock status was at $F_{8\%MSP}$
  - Intended as interim reference points
  - Moving toward ecosystem reference points
    - Jason McNamee will be presenting


F 15%
F 30%
2.98
1.03
Full F
0
2
4
6
8
1960
1970
1980
1990
2000
2010
Year

$F_{2013} = 0.27$

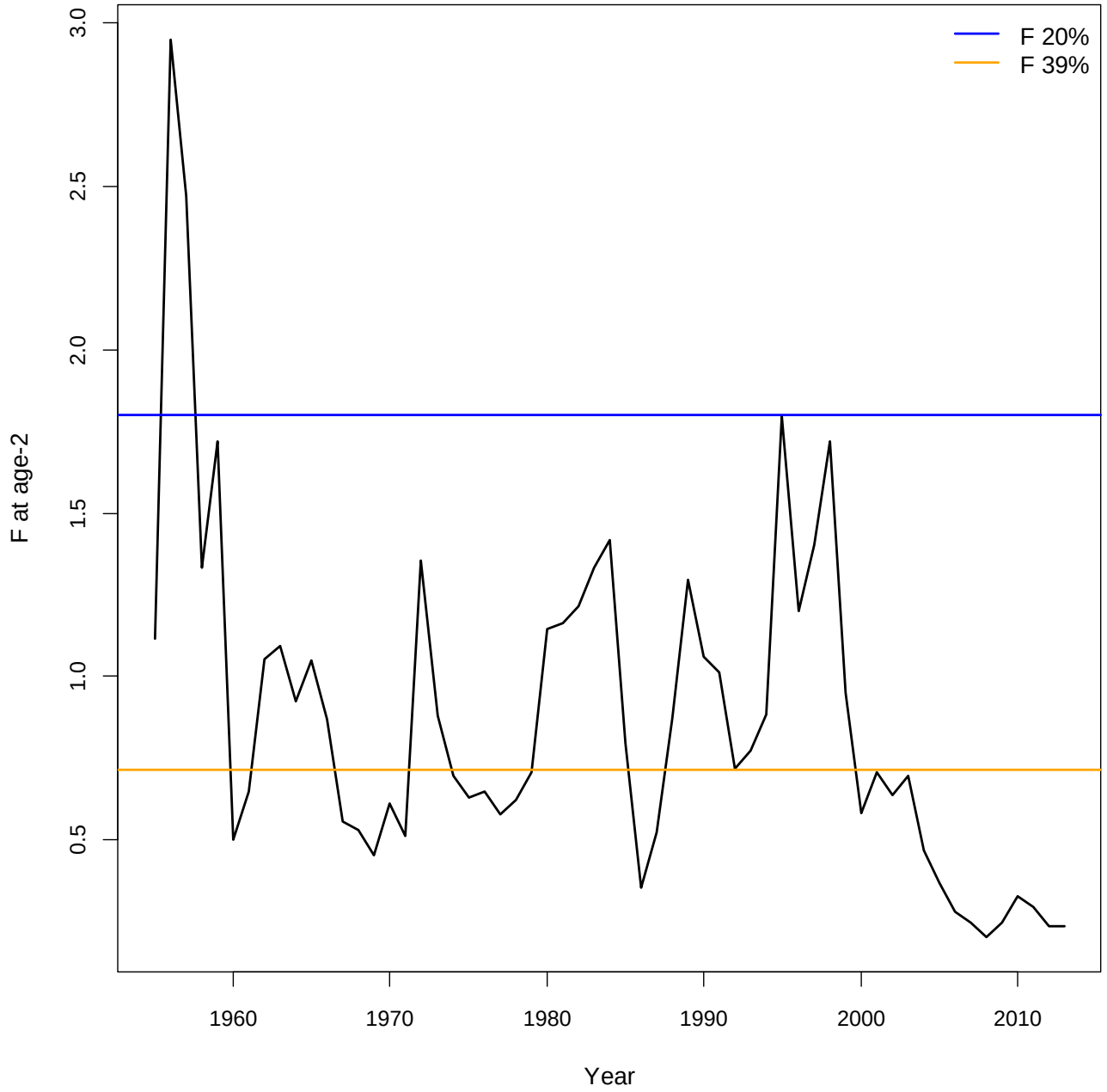

FEC 15%
FEC 30%
FEC2013 = 170,536
100,016
49,658
Fecundity
0
50000
100000
150000
200000
1960
1970
1980
1990
2000
2010
Year

Stock status

- Not overfished and overfishing not occurring based on interim reference points established by the Board
- Interim reference points were based on historical performance of the fishery
- TC recommends same historical performance process of selection, but are concerned that current adopted reference points may not be sustainable

TC recommended reference points

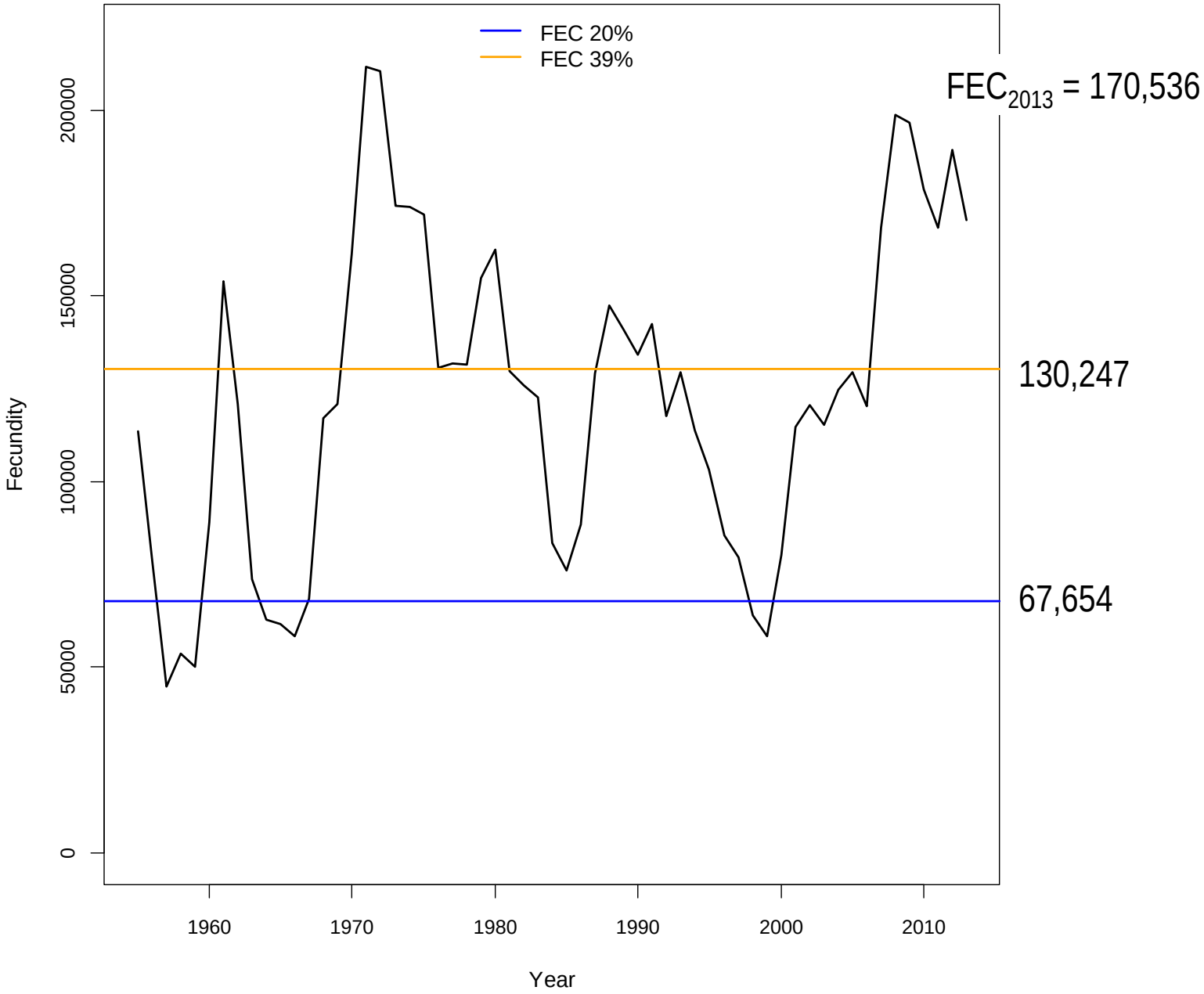
- Use F at age-2
  - Represents fishing mortality rate for largest segment of the fishery (southern reduction fleet)
  - Represents fully selected age
- Adopt MSP percentages using past fishery performance from 1960-2012
  - Threshold: Use maximum F = $F_{20\% MSP}$
  - Target: Use median F = $F_{39\% MSP}$



1.80 (max F)

0.71 (Median F)

F_{2013} = 0.24


FEC 20%
FEC 39%
FEC2013 = 170,536
130,247
67,654
Fecundity
0
50000
100000
150000
200000
1960
1970
1980
1990
2000
2010
Year

Stock status using TC recommendation

- Not overfished and overfishing not occurring
- Projections were done but haven't been updated based on recommended base run
- Projections will likely show that maintaining current harvest will not jeopardize the stock status moving forward
  - Prepared to run additional projections as directed by the Board

TOR 8: Research recommendations

Annual data collection – short term

- Continue current sampling level from bait fisheries
- Analyze sampling adequacy of reduction fishery and sample areas outside of fishery (e.g., collect age structure and biological data outside fishery range)
- Conduct ageing validation study (e.g., scale : otolith comparison; radio isotopes with archived scales)
- Conduct an ageing workshop to assess precision and error among readers (planned for March 2015)
- Conduct a comprehensive fecundity study

Annual data collection – long term

- Develop a menhaden specific coastwide fishery-independent index of adult abundance at age
- Conduct studies on spatial and temporal dynamics of spawning (how often, how much of the year, batch spawning, etc.)
- Conduct studies on productivity of estuarine environments related to recruitment

Assessment methodology

- Conduct management strategy evaluation (MSE)
- Conduct multi-objective decision analysis (MODA)
- Continue to develop an integrated length and age based model
- Continue to improve methods for incorporation of natural mortality
- Develop a seasonal spatially-explicit model, once sufficient age-specific data on movement rates of menhaden are available.

TOR 9: Recommend timing of next assessment

Timing of next assessment

- Research recommendations were made as short- or long-term
  - Short-term = 3-6 years (before the next benchmark assessment, assuming an update in 3 years)
  - Long-term = 6+ years (likely can't be completed before the next benchmark assessment)

Future directions

- TC needs to review the formal Review Workshop report
- Future work likely to occur before the next assessment
  - MSE, which can help guide reference point selection
  - Tagging data needs to be analyzed, which can provide information for a spatial stock assessment model


Questions?

Proposed Methodology to Identify Potential Ecological Reference Points

TOR #7

- “Identify potential ecological reference points that account for Atlantic menhaden’s role as a forage fish. Provide proposed methodology, a model development plan, and example results using preliminary model configurations, if time allows.”

- Finalized ERPs were not developed for the SEDAR 40 meeting but a suite of options were presented.

- Additional technical work and peer review of that work will be necessary before ERPs will be available for management use.

Overview

- Introduced the current toolbox that the BERP committee is reviewing to get some expert advice

- The presentation will focus on tools currently being examined and initial thoughts on how they can be useful for setting ERPs

- ERP types are broken in to 4 broad categories and go from simple to complex

Approach – Ecosystem Indicators

- Development of ERPs is a complex and time intensive process, but a number of methods exist that could provide more timely indicators of ecosystem health
- Not quantitative; however, qualitative reference points can provide info on status of the system as a whole
- In addition, short time frame allows for annual updates of system status
- Could be used as an interim, or even complementary, step in the development of ERPs
- Includes:
  - Environmental indicators (chlorophyll-a index, sea surface temp, climate indices like AMO and NAO)
  - Indices of forage abundance
  - Prey: Predator ratios

Peer Review Panel Comments – Ecosystem Indicators

- The panel agreed that monitoring such indicators would likely be informative

- Drawback is there is not a strong connection between these indicators and triggers for management action – the usual motivation for reference points
  - Exception is “forage species abundance” and “pred/prey ratios”, more on next slide

- Tracking these indicators will likely have value for EBFM “dashboard”, but are less important to the development of ERPs for the menhaden fishery itself

Peer Review Panel Comments – Ecosystem Indicators

- The panel viewed the following indicators as more directly relevant to the development of ERPs:
  - abundance of forage species
  - predator-prey ratios

- These have potential to be directly related to key management objectives

- Would require empirical or theoretical arguments that particular levels of forage abundance or predator-prey ratios are associated with consequences germane to ERP targets or thresholds

- It would be desirable to explicitly couple these biological indicators with models that aim to capture relevant predator-prey, or food web, dynamics

Approach – Nutrition Ref Points

- Reference points describing desirable and undesirable nutritional status of predatory fishes would be useful for judging available forage

- This concept could be developed into a systematic ERP using existing surveys for nutritional status or by development of a new coastwide approach

- Includes:
  - Body fat indices
  - Bioelectric impedance indices
  - Consumption indices (grams of prey per gram of predator)

Peer Review Panel Comments – Nutrition Ref Points

- The panel discussed these amongst the ecological indicators already discussed

- The panel noted these might be useful for ERP development if empirical relationships between nutritional status and demographic (e.g., survival, production) or economic (fish value) effects could be established

Approach – Production Models

- Biomass dynamic models with an additional sigmoidal type III predation function have been useful in exploring the role of predation for certain marine species

- Virtues of a these multispecies production models are:
  - tractability in analyzing and parameterizing

- These modeling types can generate estimates of undifferentiated prey biomass losses to key predators and estimates of prey biomass, M_2, F, surplus production (with and without predation), production, and reference points
  - Some methods can also provide time varying estimates of parameters

- These models can provide independent index-based assessments or use output from other multispecies models to provide another view of dynamics

Approach – Production Models

- Includes:
  - Steele-Henderson
  - Surplus Production Model with Time Varying r

Peer Review Panel Comments – Production Models

- The panel generally liked the suite of modeling approaches reviewed
- The panel noted that it would be desirable to explore a range of modeling strategies from simple surplus production models to more complex age-structured models
- A primary goal should be to determine the extent to which the dynamics of menhaden and their predators are connected
- Model development should consider whether important effects are likely to be only from predators, or whether menhaden abundance can also affect the abundance of its predators
- Multispecies approaches, jointly modeling the dynamics of both menhaden and menhaden's predators, will provide a more realistic representation of population dynamics and better opportunities to develop useful ERPs

Approach – Single Species Models

- Single species statistical catch-at-age model would encompass the entire spatial extent of the population
- Examples of ecological reference points based on single species assessments include *F*=0.75*M*, *F*=*M*, *B75%*, and *B40%*.
- These ERPs have been advocated for and suggested by recent forage fish documents, but are based on expert opinion of species from other locations
- Data requirements are standard stock assessment data needs like catch at age, indices of abundance, and life history parameters

Approach – Single Species Models

- Includes:
  - BAM
  - Time-Varying Natural Mortality (TVM)

Peer Review Panel Comments – Single Species Models

- The panel grouped these approaches in with both the surplus production type models and the multi-species models

- An additional note from the panel was simpler approaches may provide interim solutions until the multi-species models are ready

Approach – Multi-Species Models

- One method of interest to managers is being able to explicitly model a defined ecosystem
- This approach allows for the connection of standard stock assessment models through trophic calculations or energy budgets
- These approaches allow for direct calculation of predation on target prey species by specific predators, and in some cases allows for feedback to occur as populations change
- These approaches can be labor and data intensive and are highly complex
- Includes:
  - Multi-species Virtual Population Analysis (MSVPA)
  - Multi-species Statistical Catch-At-Age (MSSCAA)
  - Ecopath with Ecosim (EWE)

Peer Review Panel Comments – Multi-Species Models

- The panel was hesitant to encourage investment of considerable effort into developing models that include many species and many trophic levels

- The ideal approach is one of “minimum sufficient complexity” – perhaps a two trophic level predator-prey model constructed within an MSSCAA modeling framework

- The panel was not enthusiastic about utilizing a “whole food web” model such as EwE or Atlantis, at least at the expense of developing models more specifically focused on Atlantic menhaden and their primary predators

Summary

- It has been difficult to make a recommendation on which ERP would be best to adopt for Atlantic menhaden, the main task of the BERP committee

- Two main questions should be addressed before significant progress can be made on development:
  - A statement of ecological/ecosystem goals and objectives for menhaden management is provided by the Board
  - Performance of the proposed ERPs and the models used can be evaluated through multi-model comparisons, simulation testing, and completion of single and multispecies management strategy evaluations

Summary

- Although most options presented in this report are not ready for immediate management use, the BAM-based reference points that account for forage services could be adopted at any time using the most recent peer reviewed Atlantic menhaden model

- These ad hoc “forage services” reference points may be more conservative than single species reference points

- Density dependent effects and unpredictable recruitment could negate the benefits of setting aside more fish for predators

- Additional technical work and peer review of that work will be necessary before ERPs will be available for management use

- From the peer review panel: "The AMTC has done a thorough job of investigating and summarizing the options. Now it is time for managers and stakeholders to guide the way forward."

Summary

	POTENTIAL MANAGEMENT GOALS/OBJECTIVES							
APPROACH	Low disease prevalence	Adequate nutrition levels	Enough prey to support key predator species @ preferred biomass levels	Sustainable AM fishery in light of forage pressure	Better AM recruitment and/or high AM abundance at younger ages	Determine if AM are more economically valuable in the fishery or as forage	Sustainable AM commercial reduction and/or bait fisheries	Manage for a broader-age structure (may lead to re-expansion of historic range)
Ecosystem indicators	x[1]				x			
Nutrition Ref Points	x[1]	x[2]						
Production models								
Steele-Henderson			x	x			x	
Time-varying r				x			x	
Single-species models								
BAM-based forage services ERPs				x	x		x	x
BAM or SS-based time-varying M tuned to consumption index				x	x		x	x
BAM-based MSE				x[3]	x		x	x
Multi-species models								
MSVPA or MSSCAA + BAM projections			x	x	x		x	x
MSSCAA			x	x	x		x	x
Ecopath with Ecosim			x	x	x		x	x

[1]Would require data on disease prevalence be collected.

[2]Would require collection of condition data at a broader spatial scale than at present.

[3] If M is treated in a way that accounts for consumption.

Additional Slides

Peer Review Panel - General Comments

- The panel urged AMTC to continue development of ERPs
- Input from managers and stakeholders is needed about key potential management objectives that reflect a broad consideration of the role of this species in the ecosystem
- The methods developed by the ERP committee were all viewed by the panel as having merit, but:
  - emphasis should be on examining indices of predator and prey relative abundances informed by past experience with conditions deemed “acceptable” by different stakeholders, and
  - “minimum sufficient complexity” models that couple menhaden dynamics with those of the main predators
- The panel offered two case studies of broadly similar circumstances to illustrate how the challenge of developing ERPs has been confronted elsewhere.
  - Baltic Sea: sea cod – herring - sprat
  - Lake Michigan: salmon - alewife

Peer Review Panel - General Comments

- The ultimate determination of quantitative ERPs for menhaden requires a specific and comprehensive set of objectives, informed by consideration of trade-offs among potentially competing objectives

- The panel concluded that most of the technical work necessary to inform the development of ERPs can proceed with a general notion of what quantities (model outputs or ecological indicators) would be used by managers and stakeholders to evaluate these trade-offs

Atlantic Menhaden Stock Assessment Review Panel

Dec 9-11, 2014

Atlantic Beach, North Carolina

georgiaconservancy.org

Panel Membership

- John Simmonds
- Carmen Fernandez
- Anders Nielsen

Center for Independent Experts

- Michael Jones, Quantitative Fisheries Center, Michigan State University

georgiaconservancy.org

Overview

- Strong endorsement of stock assessment methods and general findings
- Recommended minor change to assessment model – new “base run”
- Support new single-species reference points
- Encourage collaborative (stakeholder-decision maker-scientist) development of Ecological Reference Points

Terms of Reference

1. Assessment data
2. Assessment methods
3. Uncertainty analysis
4. Assessment findings; reference points
5. Minority report
6. Research recommendations
7. Data/modeling improvements
8. Ecological Reference Points

Terms of Reference

1. Assessment data
2. Assessment methods
3. Uncertainty analysis
4. Assessment findings; reference points
5. ~~Minority report~~
6. Research recommendations
7. Data/modeling improvements
8. Ecological Reference Points

1. Assessment Data

- Fishery dependent data are generally used appropriately

- Considerable discussion of fishery independent data
  - Composite surveys are large advance over previous assessments
  - Concern with use of length-composition data (see ToR #2)

2. Assessment methods

- Overall SCAA modeling approach is appropriate and consistent with accepted practice
- Estimates of index length-frequency patterns did not fit data well
- AT tried several alternatives during review workshop
  - Panel concluded that “down-weighting” index length-frequency data produced better model fits
  - Recommended new base model

3. Uncertainty Analysis

- Comprehensive sensitivity, uncertainty, and retrospective analyses
- Generally, methods were appropriate and thorough
  - Supported conclusions of assessment re reference points (ToR #4)
- May be overestimating uncertainty
  - Ignored potential co-variation among uncertain quantities

4. Assessment Findings

- Panel agreed with conclusions that:
  - Stock is not overfished
  - Overfishing is not occurring
- This conclusion is supported for:
  - The new base run recommended by the Panel
  - The new Reference Points (F, FEC – 20% and 39%)

4. Assessment Findings

- Regarding Reference Point calculation, the Panel recommended:
  - Consider using an average F across ages 2-4, instead of F at age 2
  - Consider using recent biological trends for target reference points

6,7 – Research recommendations

- Consider models that allow M to vary
- Try incorporating growth and M estimation into to assessment models
- Consider age-specific selectivity estimation
- Develop multi-species models to account for predator-prey dynamics
- Conduct an MSE analysis to inform future reference points

8. Ecological Reference Points

- Panel urges AMTC to move forward on ERPs
- Process should (must?) be guided by input from stakeholders & managers
  - Objectives and performance measures
- Focus analysis on:
  - indices of predator – prey relative abundances
  - "minimum sufficient complexity" multispecies models
- Don't need to wait for stakeholder/manager **agreement** on objectives to proceed with analysis