Northeast Fisheries Science Center Reference Document 14-14
doi:10.7289/V5V9862C

2014 Assessment Update Report of the Gulf of Maine Atlantic Cod Stock

by Michael C. Palmer

October 2014

Northeast Fisheries Science Center Reference Document 14-14
doi:10.7289/V5V9862C

2014 Assessment Update Report of the Gulf of Maine Atlantic Cod Stock

by Michael C. Palmer

NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center,
166 Water Street, Woods Hole, MA 02543

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

October 2014

Northeast Fisheries Science Center Reference Documents

This series is a secondary scientific series designed to assure the long-term documentation and to enable the timely transmission of research results by Center and/or non-Center researchers, where such results bear upon the research mission of the Center (see the outside back cover for the mission statement). These documents receive internal scientific review, and most receive copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these documents.

All documents issued in this series since April 2001, and several documents issued prior to that date, have been copublished in both paper and electronic versions. To access the electronic version of a document in this series, go to *http://www.nefsc.noaa.gov/nefsc/publications/*. The electronic version is available in PDF format to permit printing of a paper copy directly from the Internet. If you do not have Internet access, or if a desired document is one of the pre-April 2001 documents available only in the paper version, you can obtain a paper copy by contacting the senior Center author of the desired document. Refer to the title page of the document for the senior Center author's name and mailing address. If there is no Center author, or if there is corporate (*i.e.*, non-individualized) authorship, then contact the Center's Woods Hole Laboratory Library (166 Water St., Woods Hole, MA 02543-1026).

Information Quality Act Compliance: In accordance with section 515 of Public Law 106-554, the Northeast Fisheries Science Center completed both technical and policy reviews for this report. These predissemination reviews are on file at the NEFSC Editorial Office.

This document may be cited as:

Palmer MC. 2014. 2014 Assessment update report of the Gulf of Maine Atlantic cod stock. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 14-14; 119 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/publications/

TABLE OF CONTENTS

Preface 2
Findings of the Peer Review Panel 4
Gulf of Maine Atlantic Cod Update Through 2013 11
State of Stock 11
Special Comments 11
References Cited 12
Appendix A. Supplemental Material 24
Appendix B. Additional Material Requested by Assessment Peer Review Panel 107

PREFACE

This update of the Gulf of Maine cod stock assessment is a streamlined document that focuses on the primary assessment information required for management. The update incorporates recent commercial and recreational landings and discard data (2012 and 2013) and recent survey information (2012-2014 spring surveys; 2012-2013 autumn surveys) into the previously approved peer-reviewed model. This report is part of a larger effort to provide more timely information on stock status for all stocks in the Greater Atlantic Region. The May 2014 peer review of the Northeast Fisheries Science Center's stock assessment science program (NEFSC) highlighted the inherent problems of managing fisheries resources when time lags exist between contemporary data and subsequent management actions. Such problems are exacerbated when stock sizes are low because delays can be detrimental both to the resource and the long-term profitability of the fishery.

As part of the effort to streamline the stock assessment process, NEFSC scientists have been developing approaches to more rapidly process landings, discards, and survey data for assessment updates in which model outputs are succinctly summarized. Stock and catch projections are based on harvest rates and model assumptions consistent with the most recent benchmark assessment and Fishery Management Council policies. The methodology has been tested with previously-conducted assessments. Gulf of Maine cod *(Gadus morhua)* was chosen as a test case for this approach because the benchmark assessment had recently been completed (NEFSC 2013). The complexity of the model formulation and management options suggested that the methods could be tested in a challenging environment. The availability of current aging data allowed NEFSC scientists to test the results using the most recent data for Gulf of Maine cod. This update revealed a continuing decline of the Gulf of Maine cod resource. Model results were checked by several NEFSC, scientists and the results were conveyed to senior managers within NEFSC and NOAA Fisheries leadership. The external peer review of the assessment update is designed to examine whether the update has been conducted according to the benchmark formulation and to provide guidance to managers on the implications of the updated assessment results.

The following report format, beginning on page 11 retains the succinctness desired in a streamlined assessment document. However, we have augmented the report with an appendix of supplemental material that includes many of the tables and figures that would be included in an operational assessment. We stress that this is neither a full benchmark nor operational assessment but recognize that this additional information may be necessary to conduct a peer-review. Thus, this assessment report represents a hybrid between a standardized assessment update and a full benchmark assessment. We note that the supplemental material provided exceeds that of most operational assessments; however, given the critical nature of this information we felt it was necessary to provide a thorough summary of data inputs and model diagnostics needed to facilitate an intensive peer-review of this assessment update. The core document for this assessment (p. 3-14) should be considered as a template for future operational assessments. Ultimately, such information can be incorporated into the Council's risk policy to allow balancing of tradeoffs among resource protection, regulatory requirements, and socio-economic concerns of industry.

The New England Fisheries Management Council sponsored a scientific peer review of the 2014 Gulf of Maine Cod Operational Update Assessment. The meeting took place at the Sheraton Harborside Hotel in Portsmouth, New Hampshire on August 28-29, 2014. The Review Panel consisted of 7 scientists representing the New England and Mid-Atlantic Fisheries Management Council's Scientific and Statistical Committees. These included Patrick Sullivan (chair), Steve Cadrin, Yong Chen, Chris Legault, Andrew Pershing, Alexei Sharov, and Michael Wilberg. The assessment update was presented by Michael Palmer (NEFSC) with scientific and logistical support provided by Paul Rago (NEFSC) and Jamie Cournane (NEFMC). The Peer Review Report consists of consensus summary findings by the Review Panel of the nine Terms of Reference provided by the Council's Assessment Oversight Panel.

The findings of the Peer Review Panel constitute the first part of the assessment report and reflect their consideration of material included in this report including Appendices A and B.

FINDINGS OF THE PEER REVIEW PANEL

The Review Panel wishes to thank Mr. Palmer for his detailed analysis and thorough presentation of the assessment. The Review Panel also wishes to thank the members of the public who attended the meeting and contributed throughout the process.

Terms of Reference

1. Update all fishery-dependent data (landings, discards, catch-at-age, etc.) and all fishery-independent data (research survey information) used as inputs in the baseline model or in the last operational assessment. Update SARC 55 analyses of the spatial distribution of fishing effort.

The Review Panel concludes that this TOR was met. The Panel did not identify any major issues in the fishery-dependent data. Commercial landings showed a declining trend consistent with a reduction in fishing effort. Close correspondence between the commercial landings data and vessel trip reports suggests that the fishery landing data accurately represent removals. Commercial discards showed a declining trend during 2012-2013. The coefficient of variation (CV) for commercial discard estimates was lower than 0.3, which is the target precision. Estimates of recreational catch have declined over time and also have low CVs (0.07 – 0.25). The Panel concluded that the fishery-dependent data used as input in the Operational Assessment had been properly updated. The Panel acknowledged that the TOR specifies that the analysis of the spatial distribution of fishing effort should be updated, but effort was not specifically examined in the assessment report because of the difficulty in defining targeted fishing effort for this fishery. However, the spatial distribution of landings was presented in the report, which is considered by the Panel as an informative proxy for the spatial distribution of fishing effort.

Survey indices remained at low levels from 2011-2014 and had CVs lower than 0.3. Presence/absence of cod in the Northeast Fisheries Science Center (NEFSC) and Massachusetts Division of Marine Fisheries (MA DMF) surveys were summarized in the assessment report. The Panel concluded that the fishery-independent data used as inputs in the Operational Assessment had been properly updated. The Panel did note two sources of uncertainty in the survey data: insufficient inshore coverage and possible changes in survey selectivity and fish availability resulting from potential changes in the distribution of cod (horizontally and vertically) in response to environmental conditions. Both of these sources of uncertainty should be evaluated in the future and the benefits of this would extend beyond cod. However, indices from Maine-New Hampshire survey were presented at the meeting, and they show similar declining trends as were evident in the other surveys. While changes in distribution have been observed, there are no indications that they are impacting survey indices for this species, but further research is warranted.

2. Estimate fishing mortality and stock size for the current year, and update estimates of these parameters in previous years, if these have been revised. Compare the results from the two model formulations used at the last benchmark.

The Review Panel concludes that this TOR was met. The two ASAP model runs, denoted M=0.2 and M-ramp, were updated with fishery and survey data from 2012 and 2013. No changes were made to either model configuration. Terminal year estimates of fishing mortality (F) on fully selected ages for 2013 were 1.33 for M=0.2 and 1.24 for M-ramp. Terminal year estimates of spawning stock biomass (SSB) in 2013 were 2,063 mt for M=0.2 and 2,432 mt for M-ramp. Both models indicate an increase in F and a decrease in SSB since the last assessment at SARC55. The increase in the estimate of F despite declining catch in the fishery is due to the revision of SSB estimates which indicate a more rapid decline than those seen in the catches. The trends in SSB are evidenced by a lack of older-aged fish in the survey indices, commercial landings, and recreational landings as well as lower overall abundance and decreased weight-at-age for the older ages in the population.

3. Evaluate the diagnostics of the model and the model fit to the data. Identify and quantify data and model uncertainty that can be considered for setting Acceptable Biological Catch limits.

The Review Panel concludes that this TOR was met. The model diagnostics were consistent with those seen in SARC55. Fits to the different model components, i.e. total catch, catch at age proportions, survey series, and survey proportions at age, were similar to those presented at SARC55. The retrospective pattern for the M=0.2 model was again slightly outside the uncertainty bounds for the terminal year. The SSC may wish to consider the magnitude and direction of this retrospective pattern when providing catch advice based on this model. Based on previous experience, the retrospective diagnostic and any attempts to adjust for it, including specifying alternative assessment models such at the M-ramp model which assumes increasing natural mortality rate, present a challenge for setting catch advice to achieve desired fishing mortality rates. However, both models indicate low stock size and high fishing mortality rates currently, as described in TOR 5.

Estimates of uncertainty in the data were used to weight their relative contribution to the model fit through the use of input coefficients of variation (CV), which were unchanged from SARC55. The CVs indicate the relative precision of the estimated catch (CV of 0.05) with more variable survey estimates (CVs of 0.4-0.6), as in SARC55. Survey information from inshore Maine and New Hampshire were not included in the model because cod from that survey have not yet been aged. Changes in the spatial distribution of cod associated with declining abundance could contribute to changes in survey selectivity. Selectivity patterns in the fishery may have also changed because of changes in stock distribution or changes in fisher behavior, due perhaps in part to recent reductions in minimum size or other regulations. There are currently too few years in the assessment with this new minimum size to allow estimation of a new selectivity block. Projections should consider the uncertainty in this potential shift to younger ages as the current selectivity patterns indicate a lag between the onset of maturity and subsequent availability to the fishery.
The panel also noted that the assumed level of the CV on the recruitment deviations (0.5) in the current assessment could contribute to overestimates of recruitment in recent years and inflate associated short-term projections and the sensitivity of these estimates to that assumption should be examined periodically in that context.

4. If appropriate, update the values of biological reference points (BRPs).

1. The reference point methods approved by SARC55 were updated.
    a. The overfishing reference point (F40% assuming M=0.2) was estimated with minor changes to the data inputs (maturity, weights, selectivity), but the value of F40% was the same as that estimated at SARC55 (F40%=0.18).
    b. Long-term projections at F=0.18 and M=0.2 were updated using 1982-2011 recruitment series, producing estimates of rebuilding targets (the SSBMSY proxy) of 47,184 mt (using the ASAP M=0.2 recruitment series) and 69,621 mt (M-ramp recruitment series).
2. The Review Panel revisited debates about reference points specified under the M-ramp model, with two perspectives on the most appropriate approach:
    a. National Standard 1 guidelines suggest that MSY reference points should be based on prevailing conditions (e.g., a M=0.4 regime). The SARC55 rebuilding target associated with the M-ramp recruitment series and M=0.2 (69,621 mt) may be unattainable if the current environmental regime continues (M=0.4).
    b. Conversely, if M has increased, the target F should be maintained or reduced to offset the increase in M.
3. As an exploration, the Panel requested estimates of F40% and the associated long-term SSB assuming M=0.4 so that the uncertainty and implications can be communicated to the entire SSC for consideration in recommending OFL and ABC. Although this was informative, the panel did not accept these as alternative approaches to reference points.

5. Evaluate stock status with respect to updated status determination criteria.

The Review Panel concludes, based on the information presented in the Operational Assessment that the stock is overfished and overfishing is occurring. This conclusion is robust to both assessment models (M=0.2 and M-ramp) as well as exploratory approaches to the M-ramp reference points.

The findings may be summarized as follows:

1. Based on the M=0.2 assessment, fully-recruited F in 2013 was 1.33 (0.89 - 1.92), which is more than seven times the FMSY proxy (0.18), and 2013 SSB was 2,063 mt (1,561 - 2,774 mt) which is 4% of the SSBMSY proxy (47,184 mt).
2. Based on the M-ramp assessment and the SARC55 approach to reference points, fully-recruited F in 2013 was 1.24 (0.84 - 1.78), which is nearly seven times the FMSY proxy (0.18), and 2013 SSB was 2,432 mt (1,819 - 3,230 mt) which is 3% of the SSBMSY proxy (69,621 mt).
3. Based on the exploratory analyses described above, fully-recruited F in 2013 was well above the FMSY proxy , and 2013 SSB was far below the SSBMSY proxy.

6. Provide a historical retrospective analysis of the performance of the assessment models and associated projections.

The Review Panel concludes that this TOR was met. Retrospective analyses were completed in 2014 assessment update for the two candidate assessment models (M=0.2 and M–ramp) with a 7-

year peel (2004-2013 terminal years). As with the assessment presented at SARC55, results indicate a retrospective error in both F and SSB with the tendency for the model to underestimate F and overestimate SSB. However, the magnitude of the retrospective bias differed between the two models, with M=0.2 model showing a greater retrospective pattern. The 7-year Mohn's rho value for SSB and F were 0.53 and -0.33 respectively for M=0.2 model and 0.17 and -0.05 respectively for M-ramp model. The Panel noted that although a strong retrospective pattern exists in M=0.2 model suggests an internal inconsistency between data sources given the assumed constant level of natural mortality, both models should be retained because at present no definitive evidence supporting the assumption of an increase in natural mortality (as depicted in the M-ramp model) has been assembled. It is also noted that despite the differences in the level of retrospective bias, both models result in similar a characterization of the status of the stock (overfished and overfishing occurring).

A historical review of assessment model performance (namely a comparison across model predictions historically used for management advice) indicated that all assessment models had similar general trends of SSB and fishing mortality, but differed in scale. The 2014 assessment update provided the lowest estimates of the SSB time series. There occurred a number of changes in the input data through time that lead to changes in scale of the estimated biomasses, but the 2014 assessment update is believed to assimilate the best available biological and catch information. Short term predictions based on the assessment presented at SARC55 indicate that terminal year estimates for the M=0.2 and M-ramp models appear to be too optimistic with respect to SSB when compared to the 2014 assessment update results due, in part, to the retrospective bias. Both models originally expected the 1,550 mt ABC to produce a low fishing mortality in 2014 given expected catch, but now revised estimates indicate that overfishing will occur in 2014 with predicted F well above FMSY.

7. Perform short-term projections, taking into account recent recruitment observations; compare results to rebuilding schedules.

The Review Panel concludes that this TOR was met. The updated assessment evaluated the stock using two models, M=0.2 and M-ramp, and both were used to make forward projections.

The Operational Assessment Report presented projections that generally used the same recruitment protocol presented at SARC55, however, it adopted a slightly modified protocol for the "hockey stick" approach (Figure 1.45 of the Operational Assessment Report). The previous protocol set the hinge point of the spawner-recruit relationship at the lowest SSB observed. For the update, the hinge point was not modified from that used in SARC55, in recognition of the lower recruitments observed in recent years. Furthermore, the time period used to estimate age 1 recruitment in year t+1 was modified from using the geometric mean of the previous 10 years to using the geometric mean of only the last 5 years in an effort to better characterize recent lower recruitment patterns.

Two methods of projection representing different sets of assumptions were considered for each model. These will be discussed in association with each model in turn.

For the M=0.2 model, one projection was developed from the base model without a retrospective adjustment as was done for SARC55, while the other used the base model with a retrospective adjustment to the 2014 abundance. Both variants use the same reference points: FMSY=0.18, SSBMSY=47,184. Although the report presents evidence that adjusting for the retrospective pattern from the previous assessment would have produced better fits relative to the estimates of current abundance, the panel elected to dismiss this variant as a basis for projections for reasons similar to those expressed at SARC55.

The two M-ramp projections differed in their assumptions about future mortality rates. One configuration (M-ramp M=0.2) assumes that mortality will return to base levels of M=0.2, the other configuration (M-ramp M=0.4) assumes that M will remain at 0.4 throughout the 10 year rebuilding period. Both used reference points based on M=0.2: FMSY = 0.18 and SSBMSY =69,621.

Using 75% FMSY, the three models produce similar catch advice for 2015 (Table 1.37 of the Operational Assessment Report), with catch recommendations ranging from 332 mt (M-ramp M=0.4) to 460 mt (M-ramp M=0.2). The catch recommendations increase by 2017, although the range expands to 509-1,016 mt.

The most significant difference between the models lies in their implication for stock rebuilding. Under M=0.2 and M-ramp M=0.2 scenarios, rebuilding in the 10 year time horizon is possible, although it requires very low fishing mortality (F=0.06). If higher natural mortality continues as implied by the M-ramp M=0.4 model, then rebuilding in 10 years is not possible, even if catch is set to zero.

Several sources of uncertainty exist in the projections. First, the spawner-recruit relationship does not include depensation (i.e. an Allee effect). If this were to occur, it would lead to even slower stock recovery. The panel also explored the consequences of basing reference points on M=0.4. As discussed above, this leads to lower SSBMSY but higher FMSY. It represents a radical rethinking of the life history and potential productivity of this stock, one that is worthy of consideration in a future benchmark assessment. If the retrospective pattern continues, then these projections will be overly optimistic. This stock assessment is scheduled to be updated next year in 2015, which will provide an opportunity to confirm or revise the projections.

8. Comment on whether assessment diagnostics—or the availability of new types of assessment input data—indicate that a new assessment approach is warranted (i.e., referral to the research track).

The Review Panel recognizes that a number of research recommendations have been previously proposed by NEFSC assessment working groups and GARM, SARC and SSC peer reviews. However, the Panel wishes to highlight the following issues because of their relevance to the current review. The Panel also notes that several sources of new information are available that could be considered under research track assessment.

To begin with, the Panel recommends that the criterion for retrospective adjustment should be re-considered in a research track assessment.

Based on SARC53, the SSC identified four topics that warranted further investigation (stock structure, recreational catch estimates, discard mortality, fishery CPUE). The recreational catch, discard and CPUE topics were addressed prior to and during SARC55. With regard to stock structure, several new sources of information are available. A workshop was held on 'Stock Structure of Atlantic Cod in the Gulf of Maine Region' (June 12-14 2012, http://www.gmri.org/mini/index.asp?ID=52&p=149). The Workshop agreed that "*all information from U.S. waters indicates that there are three genetic stocks: 1) Offshore- Eastern Georges Bank (with some connectivity with the Scotian Shelf); 2) Inshore - Northern, Spring-Spawning Complex; and 3) Inshore – Southern, Winter-Spawning Complex*" and "*cod in the eastern Gulf of Maine appear to be distinct from other groups*." Many of the workshop participants felt that there was compelling evidence that the current management units need to be revised. However, the Workshop did not reach any conclusions on what the most appropriate management units might be. Several recent publications have followed up on the research recommended by workshop:

- ☐ Pershing AJ, JH Annala, S Eayrs, LA Kerr, J Labaree, J Levin, KE Mills, JA Runge, GD Sherwood, JC Sun & S Tallack-Caporossi. 2013. The Future of Cod in the Gulf of Maine (http://www.gmri.org/resources/resource-archive/future-cod-gulf-maine)
- ☐ Cao J, SB Truesdell & Y Chen. 2014. Impacts of stock mixing on the assessment of Atlantic cod in the Gulf of Maine (ICES JMS doi: 10.1093/icesjms/fsu066).
- ☐ Zemeckis DR, D Martins, LA Kerr & SX Cadrin. 2014. 'Stock identification of Atlantic cod (Gadus morhua) in US waters: an interdisciplinary approach' (ICES JMS doi: 10.1093/icesjms/fsu032).
- ☐ Kerr LA, SX Cadrin & AI Kovach. 2014 'Consequences of a mismatch between biological and management units on our perception of Atlantic cod off New England' (ICES JMS doi: 10.1093/icesjms/fsu113).

The Council has set a priority on examining how stock structure of cod stocks may influence management in the Northeast region. If the Council finds that it is not possible to identify appropriate actions to take concerning differences in stock structure, then the Workshop and subsequent publications have suggested that a research track assessment is warranted in order to consider recent information on cod stock structure off New England for the evaluation of actions such as specifying more appropriate management units.

The Review Panel and members of the public spent considerable time at the meeting discussing the potential that Gulf of Maine cod is responding to a "regime shift" in the environment. In many ways, this view is implicit in the M-ramp model. The Gulf of Maine is near the southern end of the range of cod, and the Gulf of Maine has experienced rapid warming (Mills et al., 2013). Developing a deeper understanding of how environmental factors influence cod would help with the interpretation of alternate model scenarios and management options. Assessment models that specifically incorporate environmental factors such as temperature, prey availability, or the presence or influence of predators could be used to better evaluate the effects of environment on stock dynamics and the assessment.

Additionally, the Review Panel noted that data from the Maine-New Hampshire survey may be available for the next research track assessment if the aging is completed. The aggregate index from this survey indicated a similar decreasing pattern as that shown in the other surveys that are included in the assessment.

Mills, K. E., A. J. Pershing, C. J. Brown, Y. Chen, F. Chiang, D. S. Holland, S. Lehuta, J. A. Nye, J. C. Sun, A. Thomas, and R. A. Wahle. 2013. Fisheries management in a changing climate: lessons from the 2012 ocean heat wave. Oceanography 26:191-195.

9. Should the baseline model fail when applied in the operational assessment, provide guidance on how stock status might be evaluated. Should an alternative assessment approach not be readily available, provide guidance on the type of scientific and management advice that can be.

As indicated by the statements made in the previous Terms of Reference for this report, the Review Panel decided to go forward with the two baseline models, the M=0.2 model and the M-ramp model, for providing management advice and guidance on stock status. Please refer to the comments made for the other Terms of Reference for further details.

GULF OF MAINE ATLANTIC COD UPDATE THROUGH 2013

This assessment of the Gulf of Maine Atlantic cod (Gadus morhua) stock (Figure 1) is an update of the existing 2012 SARC 55 benchmark assessment (NEFSC 2013). This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, and the analytical assessment models through 2013. Additionally, reference points and stock projections have been updated through 2017. In what follows, there are 2 population assessment models brought forward from the 2012 benchmark assessment, the M=0.2 (natural mortality, M=0.2) and the M-ramp (M ramps from 0.2 to 0.4) assessment models. No changes have been made to the data preparation methods, assessment model configurations or reference point/projection formulations (see NEFSC 2013 for full details).

State of Stock

The Gulf of Maine Atlantic cod stock is overfished and overfishing is occurring. Spawning stock biomass (SSB) in 2013 is estimated to be below 2,500 mt under both the M=0.2 and M-ramp model scenarios (Table 1, Figure 2). These 2013 spawning biomass levels are the lowest ever estimated and are at 4% or 3% of the SSB_{MSY} proxy (47,184 mt or 69,621 mt) in the M=0.2 or M-ramp models, respectively (Table 2). The 2013 fully selected fishing mortality is estimated to be greater than 1.2 under both models which is more than 6 times greater than the F_{MSY} proxy (0.18 for both models). Fishing mortality is near all time highs despite the fact that fishery catches are at the lowest levels in the time series (Figure 3). The Gulf of Maine cod stock is in poor condition.

Special Comments

- Gulf of Maine cod survey indices are at time series lows (Figure 4).
  - The 2011-14 NEFSC spring survey abundance indices are the 4 lowest in the time series. The 2014 index is the lowest of the time series and is not included in the assessment model.
  - The 2012-13 NEFSC fall survey abundance indices are the 2 lowest in the time series.
  - The 2013 MADMF spring survey is the lowest in the time series.

- The fishing year 2014 Gulf of Maine cod Acceptable Biological Catch (ABC) of 1,550 mt exceeds the overfishing threshold of F=0.18. Fishing year 2015 catches would have to be substantially decreased to avoid exceeding the projected Overfishing Limit (OFL) (harvest at $F_{MSY\text{-}proxy}$=0.18; Table 3). To meet rebuilding targets (rebuild to SSB_{MSY} by 2024), 2015 catches would need to be reduced considerably lower.

- Declining spawning stock biomass and truncation of the age-structure (Figure 5) could compromise the future recruitment success of this stock. Recruitment over the last 5 years (2009-2013) has been well below the long-term recruitment levels (Figure 6). If recent weak recruitment of Gulf of Maine cod continues, productivity and rebuilding of the stock will be less than projected. Projections shown in Table 3 have assumed 1982-2011 median recruitment (M=0.2~ 4.6 million fish, M-ramp~ 9.1 million fish) consistent with the guidance from SARC 55. Stock projections may be optimistic.

- The past 2 Gulf of Maine cod assessments have overestimated spawning stock size and underestimated fishing mortality (Figure 7). There were model diagnostic issues present in the both the SARC 53 (2011) and SARC 55 (2012) assessments (NEFSC 2013) that suggested the model results were optimistic; specifically, the fits of the assessment models to the all 3 survey indices exhibited negative residuals in 2010-2011 (model estimates of population size exceeded survey observations; Figure 8). This residual pattern does not exist in the 2014 update, though there is still a large negative residual associated with the 2013 MADMF spring survey observation. Past model performance should be accounted for when ascribing the appropriate level of scientific uncertainty to the 2014 assessment results.

REFERENCES CITED

Northeast Fisheries Science Center (NEFSC). 2012. 53rd Northeast Regional Stock Assessment Workshop (53rd SAW) Assessment Summary Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-03; 33 p.

Northeast Fisheries Science Center (NEFSC). 2013. 55th Northeast Regional Stock Assessment Workshop (55th SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13-11; 845 p.

Table 1. Catch and status table for Gulf of Maine Atlantic cod *(Gadus morhua)*. All weights are in thousands of metric tons, age-1 recruitment is in millions of fish and F_{full} is the fishing mortality on fully selected ages. *Note that reported discards include only dead discards (i.e., gear-specific survival of discarded fish is accounted for).*

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Commercial landings	3.8	3.6	3.0	4.0	5.4	6.0	5.4	4.6	2.8	1.0
Commercial discards	0.6	0.3	0.3	0.2	0.3	0.8	0.2	0.1	0.1	0.1
Recreational landings	1.2	1.3	0.7	1.0	1.3	1.4	1.8	1.8	0.6	0.6
Recreational discards	0.2	0.3	0.2	0.3	0.3	0.3	0.4	0.3	0.1	0.1
Catch used in assessment	5.8	5.4	4.3	5.5	7.4	8.4	7.7	6.8	3.5	1.7
ASAP (M=0.2)										
Spawning stock biomass	8.8	7.4	7.0	8.8	10.1	10.5	8.9	5.8	3.0	2.1
F_{full}	0.7	0.9	0.7	0.7	0.9	1.0	1.1	1.6	1.8	1.3
Recruitment (age 1)	6.2	3.8	6.2	4.6	3.2	2.1	1.3	1.5	2.6	0.7
ASAP (M-ramp)										
Spawning stock biomass	12.2	10.1	9.6	11.8	13.1	13.3	10.8	6.9	3.6	2.4
F_{full}	0.5	0.7	0.6	0.6	0.8	0.9	0.9	1.4	1.6	1.2
Recruitment (age 1)	14.0	8.3	13.6	9.7	6.5	4.1	2.5	2.8	4.4	1.1

Table 2. Biological reference points and stock status for Gulf of Maine Atlantic cod *(Gadus morhua)* based on SARC 55 benchmark assessment (NEFSC 2013) and the revised 2014 updated assessment. Intervals shown are the 5th and 95th percentiles. *Note that the fishing mortality probability intervals reported in the SARC 55 report were incorrect, the table below contains the corrected interval values.*

Assessment	Proxy reference points	M=0.2	M-ramp
SARC 55	$F_{full,2011}$	0.86 (0.58 - 1.17)	0.90 (0.62 - 1.23)
	F_{MSY}	0.18	0.18
	$F_{full,2011}/F_{MSY}$	4.78	5.00
	Overfishing	Yes	Yes
	SSB_{2011} (mt)	9,903 (7,644 - 13,503)	10,221 (7,943 - 13,676)
	SSB_{MSY} (mt)	54,743 (40,207 - 73,354)	80,200 (64,081 - 99,972)
	SSB_{2011}/SSB_{MSY}	0.18	0.13
	Overfished	Yes	Yes
	MSY (mt)	9,399 (6,806 - 13,153)	13,786 (10,900 - 17,329)
	Median age1 recruitment (000s)	5,254 (2,206 - 14,727)	9,446 (4,480 - 16,321)
2014 update	$F_{full,2013}$	1.33 (0.89 - 1.92)	1.24 (0.84 - 1.78)
	F_{MSY}	0.18	0.18
	$F_{full,2013}/F_{MSY}$	7.39	6.89
	Overfishing	Yes	Yes
	SSB_{2013} (mt)	2,063 (1,561 - 2,774)	2,432 (1,819 - 3,230)
	SSB_{MSY} (mt)	47,184 (32,903 - 67,045)	69,621 (53,349 - 89,302)
	SSB_{2013}/SSB_{MSY}	0.04	0.03
	Overfished	Yes	Yes
	MSY (mt)	7,753 (5,355 - 11,162)	11,388 (8,624 - 14,750)
	Median age1 recruitment (000s)	4,665 (1,414 - 14,649)	9,173 (2,682 - 16,262)

Table 3. Short-term projections (2015-2017) of total fishery yield and spawning stock biomass for Gulf of Maine Atlantic cod *(Gadus morhua)* based on 4 different harvest scenarios ($F_{MSY\text{-}proxy}$, 75% $F_{MSY\text{-}proxy}$, $F_{rebuild}$, $F_{no\ action}$). These projections have assumed 1982-2011 median recruitment (M=0.2~ 4.6 million fish, M-ramp~ 9.1 million fish). Catch in 2014 has been set at the fishing year 2014 Acceptable Biological Catch (ABC) of 1,550 mt. There are 2 sets of projections for both the M=0.2 and M-ramp models. For the M=0.2 model, the first projection assumes 2014 conditions as determined from the M=0.2 model with no adjustment for retrospective error, the second applies a retrospective adjustment based on ρ=0.53 ((1/1+ ρ)=0.65). The 22 M-ramp projections differ in the assumed natural mortality rate in subsequent years. One is set at M=0.2 while the other is set at M=0.4 to bracket the range of natural mortality rates used in the M-ramp model. *Note that under the M-ramp, M=0.4 scenario, the stock cannot rebuild by the 2024 rebuilding date at F=0.*

Harvest strategy	Year	Input	M=0.2 model						M-ramp model					
			No retro adjustment			Retrospective adjustment			M=0.2			M=0.4		
			Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}
F_{MSY}	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,684	0.86	1,550	1,597	1.55	1,550	3,022	0.80	1,550	2,844	0.90
	2015	Projection	517	3,508	0.18	262	1,857	0.18	604	4,460	0.18	436	3,395	0.18
	2016	Projection	810	5,826	0.18	458	3,583	0.18	1,057	8,611	0.18	639	5,581	0.18
	2017	Projection	1,345	9,562	0.18	903	6,965	0.18	2,034	15,346	0.18	1,062	8,778	0.18
75% F_{MSY}	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,684	0.86	1,550	1,597	1.55	1,550	3,022	0.80	1,550	2,844	0.90
	2015	Projection	408	3,529	0.14	206	1,868	0.14	475	4,486	0.14	344	3,414	0.14
	2016	Projection	652	5,957	0.14	368	3,653	0.14	848	8,769	0.14	512	5,679	0.14
	2017	Projection	1,095	9,875	0.14	730	7,146	0.14	1,644	15,724	0.14	856	8,988	0.14
$F_{rebuild}$	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,684	0.86	1,550	1,597	1.55	1,550	3,022	0.80	1,550	2,844	0.90
	2015	Projection	389	3,530	0.13	186	1,868	0.13	465	4,484	0.14	***0***	***3,479***	***0.00***
	2016	Projection	623	5,988	0.13	333	3,684	0.13	831	8,764	0.14	***0***	***6,034***	***0.00***
	2017	Projection	1,053	9,969	0.13	666	7,249	0.13	1,609	15,840	0.14	***0***	***9,833***	***0.00***
$F_{no\ action}$	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,684	0.86	1,550	1,597	1.55	1,550	3,022	0.80	1,550	2,844	0.90
	2015	Projection	1,550	3,272	0.62	1,550	1,531	2.55	1,550	4,254	0.51	1,550	3,135	0.76

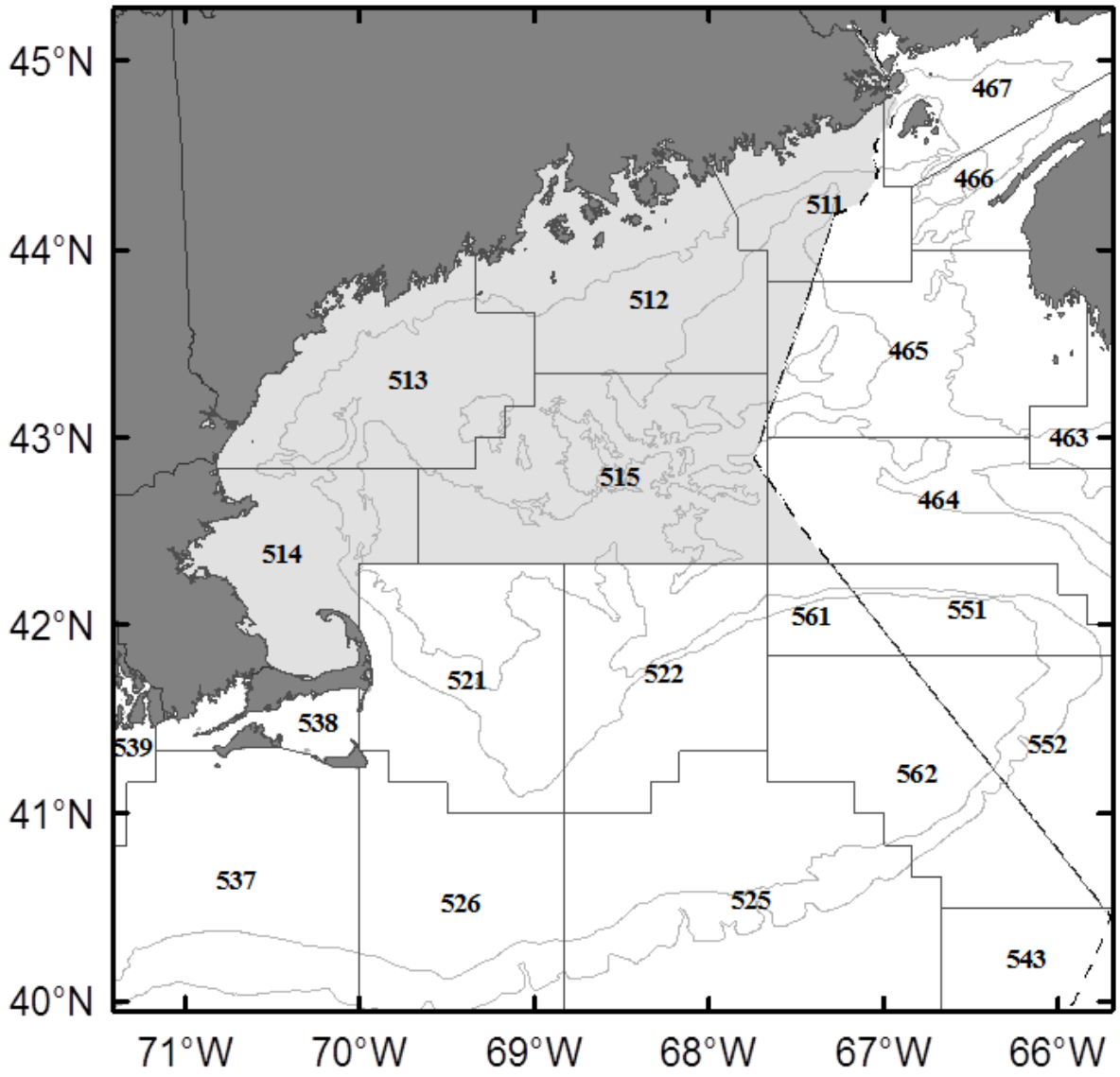

Figure 1. Map of the Gulf of Maine Atlantic cod (*Gadus morhua*) management and assessment area (shaded gray). The United States exclusive economic zone (EEZ) is defined by the dashed line.

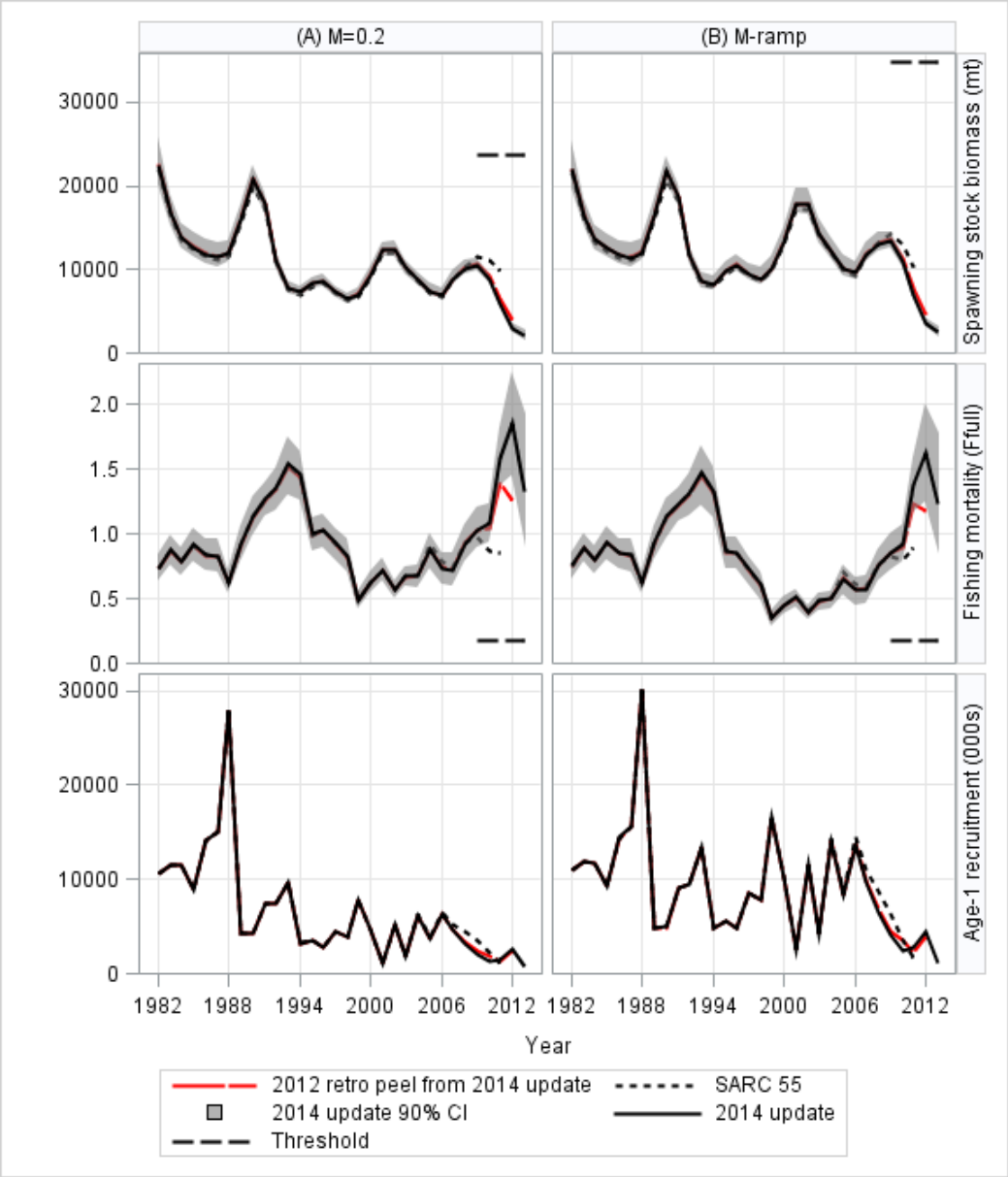

Figure 2. Estimated trends in the spawning stock biomass, fishing mortality and age-1 recruitment of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013 based on the M=0.2 (A) and M-ramp (B) model scenarios. *Note that the SARC 55 assessment time series extends only through 2011. The 2012 retrospective peel from the 2014 assessment model is shown to illustrate the incremental change in model results following the 2012 SARC 55 assessment.*

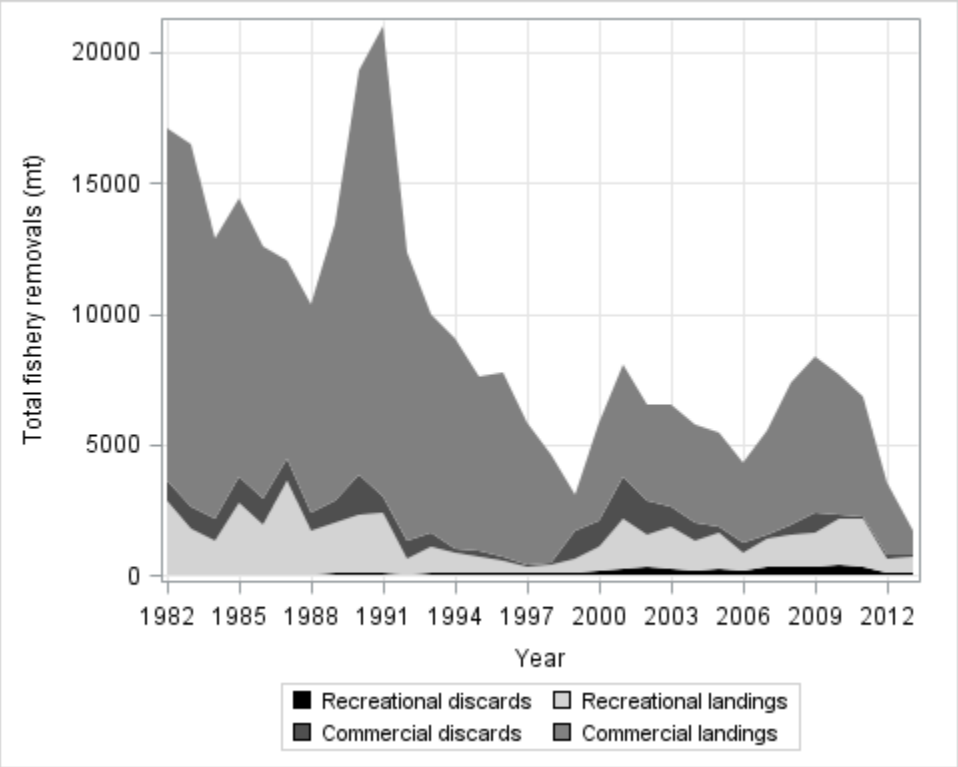

Figure 3. Total fishery removals of Gulf of Maine Atlantic cod (*Gadus morhua*) between 1982 and 2013 by fleet (commercial and recreational) and disposition (landings and discards). *Note that reported discards include only dead discards (i.e., gear-specific survival of discarded fish is accounted for).*

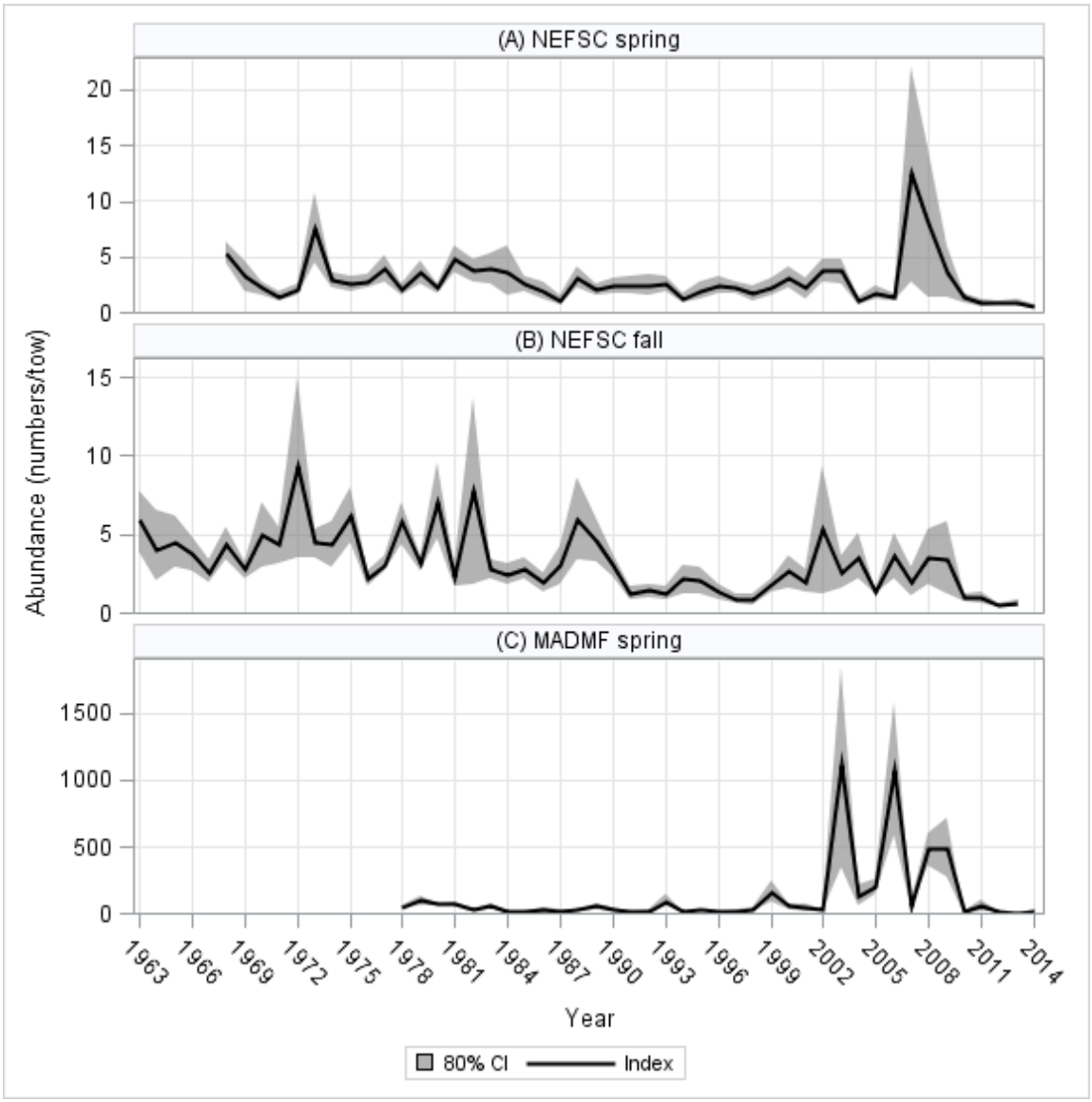

Figure 4. Gulf of Maine Atlantic cod (*Gadus morhua*) indices of abundance between 1963 and 2014 for the Northeast Fisheries Science Center (NEFSC) spring (A) and fall (B) bottom trawl surveys and the Massachusetts Division of Marine Fisheries (MADMF) spring (C) bottom trawl survey. ***Notes: (1) these survey indices reflect the aggregate indices across all ages - assessment model inputs include only ages 1 to 9^{+} for the NEFSC survey and ages 1 to 6 for the MADMF spring survey; (2) the spring 2014 indices were not incorporated into the population model.***

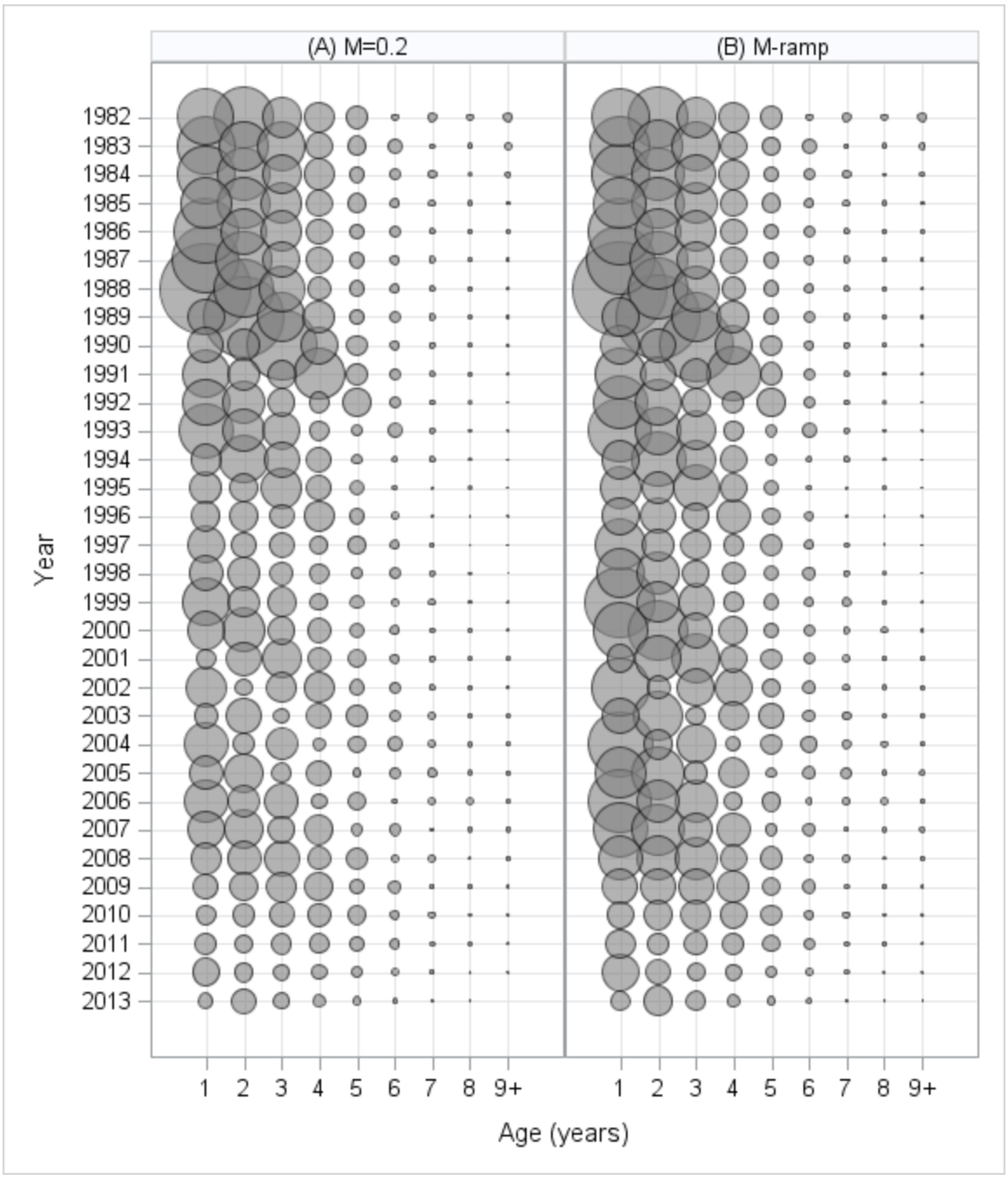

Figure 5. Estimated population numbers-at-age of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013 based on the M=0.2 (A) and M-ramp (B) model scenarios. *Note that the maximum age is a plus group.*

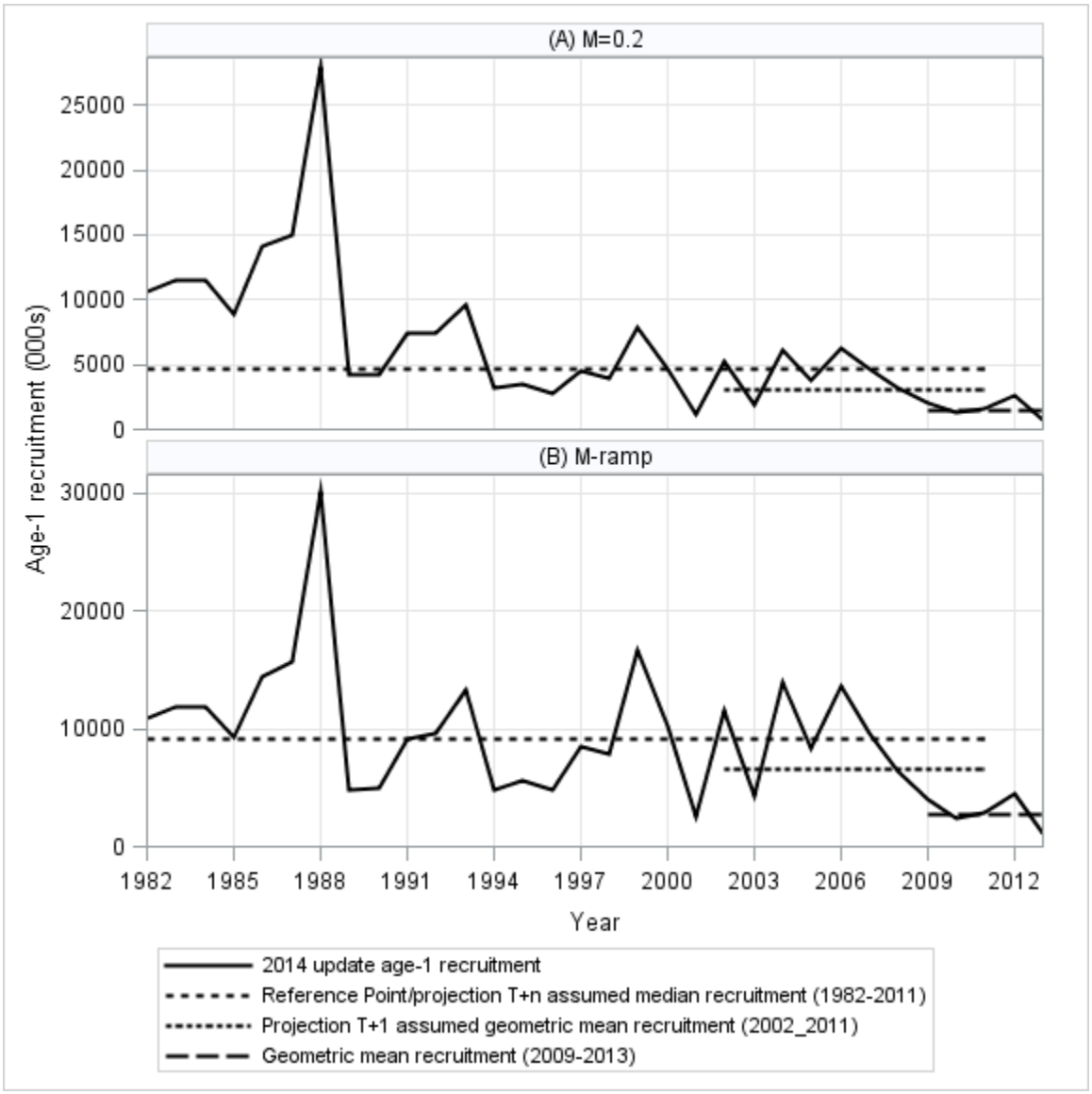

Figure 6. Comparison of the estimated Gulf of Maine Atlantic cod (*Gadus morhua*) age-1 recruitment from 1982 to 2013 based on the M=0.2 (A) and M-ramp (B) model scenarios to the recruitment assumptions applied in the stock projections.

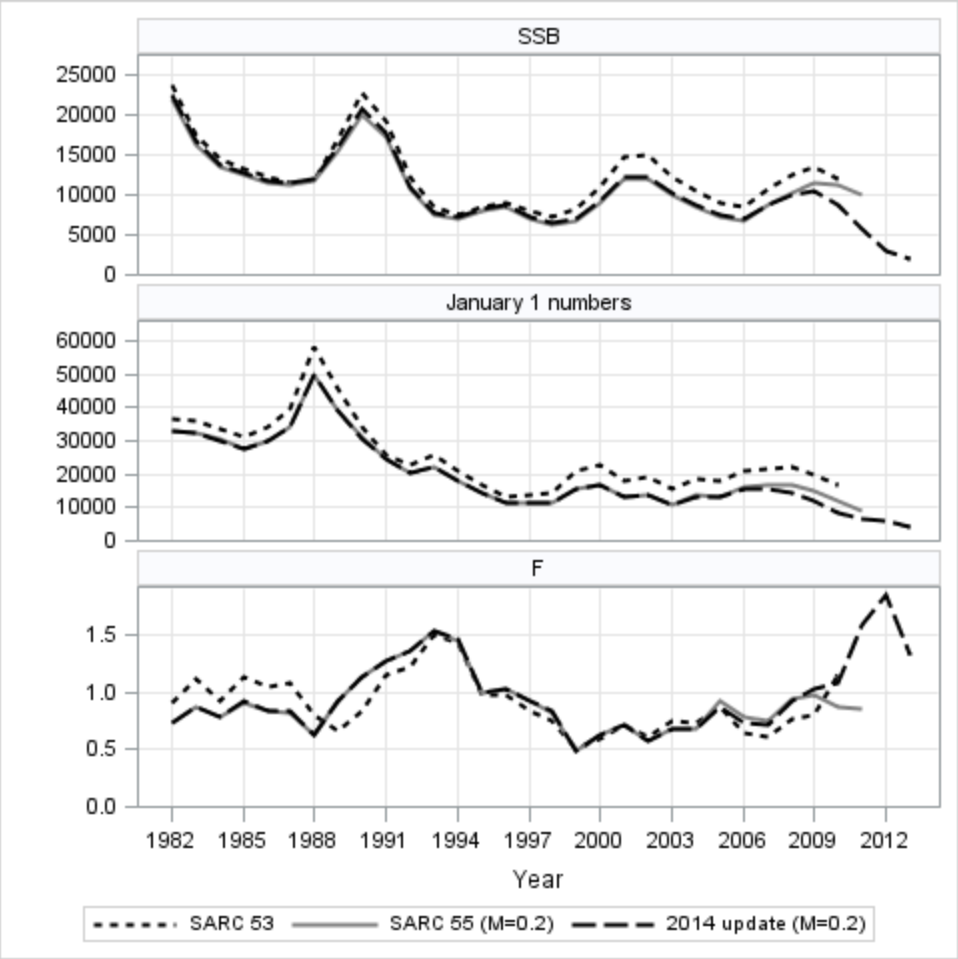

Figure 7. Historical model retrospective analysis comparing the model results (spawning stock biomass, January 1 population numbers and fishing mortality) of the SARC 53 (2011), SARC 55 (2012) and 2014 update assessments of the Gulf of Maine Atlantic cod (*Gadus morhua*) (NEFSC 2012, 2013). *Note that for the SARC 55 and 2014 update, only results for the M=0.2 model are shown to provide a direct comparison to the SARC 53 model results.*

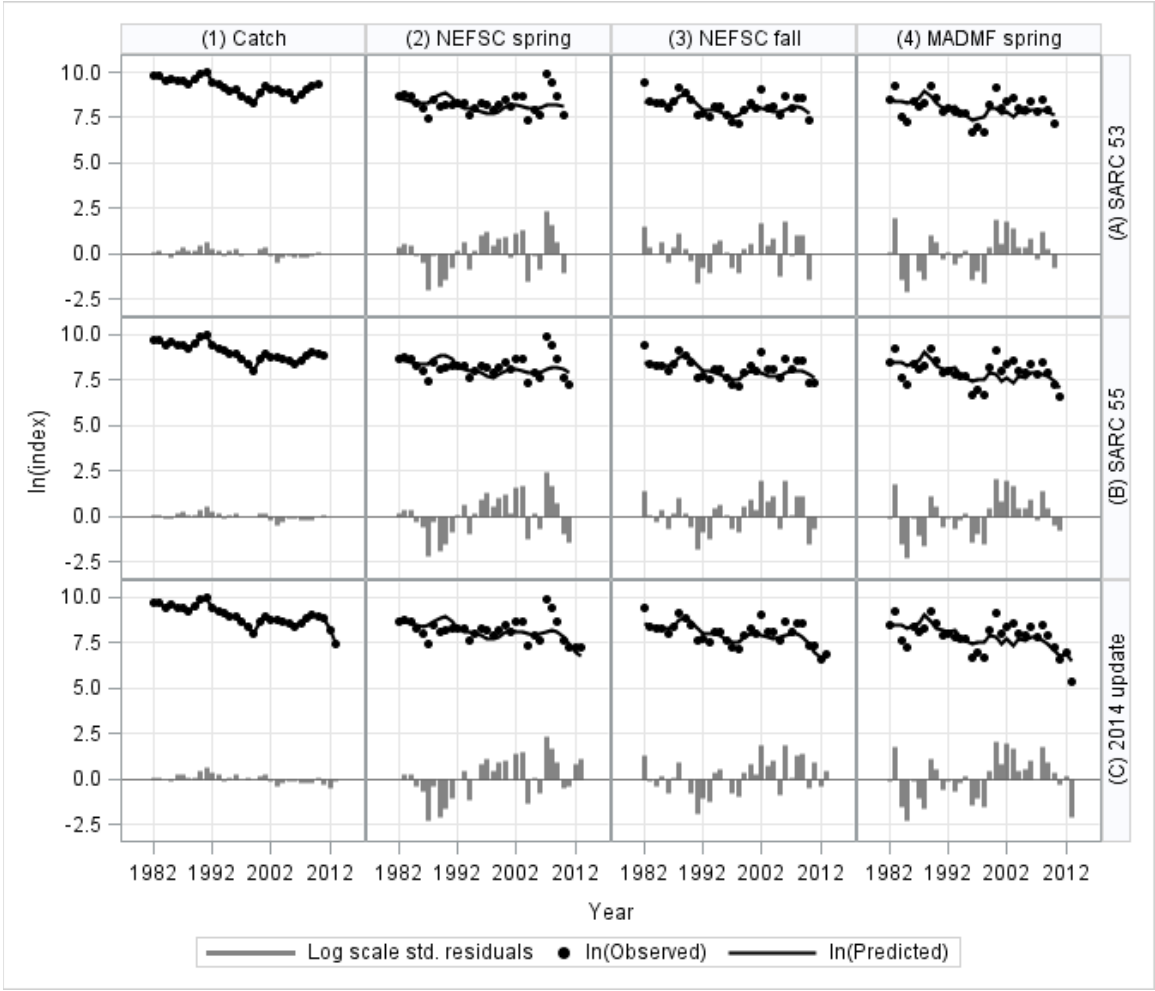

Figure 8. Comparison of model fits to aggregate catch and survey indices and the corresponding standardized residuals from the SARC 53 (2011), SARC 55 (2012) and 2014 update assessments of the Gulf of Maine Atlantic cod (*Gadus morhua*) (NEFSC 2012, 2013). *Note that for the SARC 55 and 2014 update, only model fits for the M=0.2 model are shown to provide a direct comparison to the SARC 53 model fits.*

APPENDIX A. SUPPLEMENTAL MATERIAL

This appendix contains all input data and model diagnostics associated with the 2014 update of the Gulf of Maine Atlantic cod (*Gadus morhua*) stock assessment. This is an update of the existing 2012 SARC 55 benchmark assessment. No changes have been made to the data preparation methods, assessment model configurations or reference point/projection formulations. Readers should consult the reference below for a full description of data preparation methods and model configurations.

Northeast Fisheries Science Center (NEFSC). 2013. 55th Northeast Regional Stock Assessment Workshop (55th SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13-11; 845 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

Tables

Table A1. Summary of major regulatory actions that have affected the Gulf of Maine Atlantic cod (*Gadus morhua*) fishery since 1973.

Date	Regulatory action	Cod end minimum mesh size (in)	Minimum fish size (in)		Commercial trip limits	Recreational trip limits	Closures	Differential DAS Counting
			Commercial	Recreational				
01/01/73		4.5	?	?				
01/01/77	Groundfish FMP	5.125	16	16				
01/01/82			17	15				
01/01/83		5.5						
01/01/89			19	19				
04/01/92					Shrimp trawl fishery: Nordmore grate regulation, groundfish bycatch prohibited			
05/01/94	Amendment 5	6.0						DAS monitoring w/ reduction schedule, mandatory reporting
05/01/96	Amendment 7			20				Accelerated DAS reduction
05/01/97	Framework 20			21	1000 lbs day, 1500 lbs/day			
05/01/98	Framework 25				700 lbs/day		WGOM (Jeffreys Ledge, Stellwagen Bank)	
06/25/98					400 lbs/day			
02/01/99	Framework 26						Additional month-block closures for February to April	
05/01/99	Framework 27	6.5 square/6.0 diamond			200 lbs/day			
05/28/99					30 lbs/day			
08/03/99	Interim rule				100 lbs/day			
01/05/00	Framework 31				400 lbs/day (4000 lb/trip)		Additional month-block closures for February	
06/01/00	Framework 33	6.5 square/6.5 diamond						
11/01/00							One month closure of Cashes Ledge	
05/01/02	Interim rule		22	23	500 lb/day (4000 lb/trip)	10 cod/person	Additional month-block closures for May - June 2003; Cashes Ledge Closed year round	20% reduction in DAS
06/01/02	Revised interim rule		19					
08/01/02	Emergency rule		22			5 - 10 cod/person (seasonal)		
05/01/04	Amendment 13				800 lb/day (4000 lb/trip)		WGOM, Cashes Ledge and rolling closures continued	Further reduction in DAS
11/22/06	FW 42			24		Possession prohibited November to March 31st		DAS counted 2:1 in inshore GOM
05/01/09	Interim rule					Possession prohibited November to April 15		
05/01/10	Amendment 16				Common pool: 800 lb/day (4000 lb/trip)	10 cod/person, possession prohibited November to April 15	Some changes to rolling closures for sector vessels	DAS counted in 24 -hour blocks; no differential DAS counting except as AMs
05/01/12				19		9 cod/person, possession prohibited November to April 15		
07/01/13			19					Various DAS and trip limit adjustments to common pool vessels
05/01/14				21		9 cod/person, possession prohibited September to April 15		

Table A2. Estimates of Gulf of Maine of Atlantic cod (*Gadus morhua*) catch (mt) by fleet (commercial, recreational) and disposition (landed, discarded) from 1982 to 2013. *Discard amounts reflect application of mortality assumptions adopted for the SAW/SARC 55 assessment (NEFSC 2013; recreational = 30%, commercial longline = 33%, commercial trawl = 75%, commercial gillnet = 80%).*

Year	Recreational discards (mt)	Recreational landings (mt)	Commercial discards (mt)	Commercial landings (mt)	Total catch (mt)
1982	8	2,817	805	13,466	17,096
1983	18	1,773	829	13,867	16,487
1984	17	1,267	859	10,725	12,868
1985	17	2,766	963	10,645	14,391
1986	10	1,928	964	9,670	12,572
1987	48	3,547	884	7,526	12,005
1988	14	1,689	683	7,948	10,333
1989	76	1,957	787	10,551	13,371
1990	67	2,247	1,561	15,440	19,314
1991	68	2,287	664	17,959	20,978
1992	35	624	669	11,019	12,347
1993	102	1,012	480	8,367	9,960
1994	101	722	208	8,030	9,060
1995	96	627	235	6,607	7,566
1996	81	499	157	7,020	7,757
1997	59	236	87	5,432	5,814
1998	72	353	78	4,074	4,578
1999	72	577	1,022	1,407	3,078
2000	138	967	946	3,772	5,823
2001	227	1,968	1,545	4,314	8,055
2002	287	1,255	1,329	3,638	6,509
2003	282	1,608	741	3,866	6,497
2004	201	1,151	631	3,782	5,766
2005	267	1,347	269	3,558	5,441
2006	194	702	342	3,029	4,268
2007	317	1,042	178	3,990	5,527
2008	315	1,267	349	5,443	7,375
2009	292	1,357	752	5,953	8,355
2010	384	1,758	171	5,356	7,670
2011	334	1,799	99	4,598	6,830
2012	96	571	93	2,759	3,520
2013	126	587	51	951	1,715

Table A3. Total numbers of Gulf of Maine Atlantic cod (*Gadus morhua*) lengths sampled from commercial landings by market category and year between 1969 and 2013. Sampling intensity is expressed as metric tons landings per 100 lengths sampled (*200 metric tons per 100 lengths is an unofficial NAFO/ICNAF standard*). Cells shaded in grey indicate where lengths were aggregated semi-annually. Cells shaded orange indicate where lengths were aggregated annually. Aggregation occurred when length sampling was insufficient; a general criterion of 100 lengths/block was used to determine sufficiency.

Year	Scrod (0814)				Market (0813)				Large (0811)				Unclassified (0815)				Total lengths	Landings (mt)	Metric tons/100 lengths
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
1969																114	114	7,828	6867.0
1970					100								287				387	7,512	1941.0
1971																	0	7,193	
1972																	0	6,786	
1973																	0	6,061	
1974	102							101									203	7,425	3657.8
1975		186		62													248	8,676	3498.4
1976														101		56	157	9,878	6291.5
1977	101	66	402	1012		277	371	64		80	152						2,525	11,993	475.0
1978	407	455	65		370	304	500	100			55						2,256	11,890	527.0
1979	56		58	116		100	237	188									755	10,972	1453.3
1980	213	100	51										212				576	12,515	2172.7
1981	52	57	81	236			82	471			210						1,189	12,382	1041.3
1982	401	488	484	308	418	309	665	345		208	64	158	97	102	122		4,169	13,466	323.0
1983	712	626	578	253	396	1021	583	200	56	205	514	97		53			5,294	13,867	261.9
1984	344	271	342	378	396	264	443	551	75	552	204	105	94				4,019	10,725	266.9
1985	263	352	449	241	837	565	677	351	542	341	263	403					5,284	10,645	201.5
1986	229	264	319	160	520	608	834	329	75	279	269	183					4,069	9,670	237.6
1987	281	232	165	271	344	490	351	399	157	150	258	90					3,188	7,526	236.1
1988	298	99	215	249	59	539	291	481	59	194	135						2,619	7,948	303.5
1989	154	170	201	174	401	204	506	***409***	195	102	104	98					2,718	10,551	388.2
1990	156	362	165	260	409	715	370	300		136	108						2,981	15,440	517.9
1991	100	533	192	215	514	1034	***1137***	275		302	273	101					4,676	17,959	384.1
1992	***118***	443	320	180	633	725	592	263	297	142	75	298					4,086	11,019	269.7
1993	159	173	174	55	97	173	393	106	65	87	141	63		67			1,753	8,367	477.3
1994		102	107	181	97	576	324	567		184	322	198					2,658	8,030	302.1
1995	211	196	107	249	170	807	215	224		280		98					2,557	6,607	258.4
1996	278	275	491	691	596	961	1165	1178	68	200	303	280					6,486	7,020	108.2
1997	520	848	188	751	1235	1071	991	880	190	539	201	145					7,559	5,432	71.9
1998	295	383		101	911	951	1103	436	99		175	82					4,536	4,074	89.8
1999	385				311	108	58		***211***								1,073	1,407	131.2
2000	694	304	294	426	1588	1167	409	924				115					5,921	3,772	63.7
2001	189	215	216	404	428	984	697	1548	172	474	892	898					7,117	4,314	60.6
2002	106	80		39	1365	260	411	395	1192	397	524	494					5,263	3,638	69.1
2003	254	66	214	73	1121	705	1762	1402	1179	1432	1583	1688					11,479	3,866	33.7
2004	361	299	233	73	1384	1887	1288	994	2049	***1419***	283	940	25				11,235	3,782	33.7
2005	73	193	324	506	919	1095	1384	1362	790	709	1330	1478		61	180		10,404	3,558	34.2
2006	494	167	294	125	1291	1412	1075	753	***1552***	871	1348	1388					10,770	3,029	28.1
2007	291	174	315	293	584	1188	1521	1488	654	811	1887	1417			66		10,689	3,990	37.3
2008	536	251	203	85	969	1403	1196	927	712	1314	1753	1573					10,922	5,443	49.8
2009	407		62	141	800	1601	***1791***	2601	954	***1656***	2304	2554					14,871	5,953	40.0
2010	150	53		199	2679	1762	2788	1741	1428	2106	2561	1984					17,451	5,356	30.7
2011	287	320	144	577	2005	2848	2674	3260	1141	2250	1884	1292					18,682	4,598	24.6
2012	458	63		322	1417	2346	1605	833	1374	855	826	908					11,007	2,759	25.1
2013	236	181	282	385	787	1554	1259	1287	1165	521	225	189					8,071	951	11.8

Table A4. Total numbers of Gulf of Maine Atlantic cod (*Gadus morhua*) ages sampled from commercial landings by quarter between 1977 and 2013.

Year	Quarter					Landings	Metric
	1	2	3	4	Total	(mt)	tons/100
1977	20	114	229	205	568	11992.8	2111.4
1978	124	124	115	20	383	11890.1	3104.5
1979	10	20	48	52	130	10972.3	8440.2
1980	35	27	15		77	12514.9	16253.1
1981	12	15	67	170	264	12381.6	4690.0
1982	194	237	251	183	865	13465.9	1556.7
1983	277	513	400	158	1348	13867.4	1028.7
1984	245	350	296	337	1228	10725.3	873.4
1985	446	377	397	323	1543	10645.3	689.9
1986	243	360	398	173	1174	9669.6	823.6
1987	252	229	226	228	935	7526.2	804.9
1988	131	223	187	196	737	7948.2	1078.5
1989	206	129	203	165	703	10550.7	1500.8
1990	140	302	171	150	763	15439.7	2023.6
1991	126	447	385	152	1110	17959.0	1617.9
1992	220	298	264	178	960	11019.4	1147.9
1993	72	130	186	49	437	8366.7	1914.6
1994	21	195	149	308	673	8030.2	1193.2
1995	144	311	101	126	682	6606.8	968.7
1996	190	315	426	449	1380	7019.8	508.7
1997	395	632	331	285	1643	5432.1	330.6
1998	192	325	276	199	992	4074.3	410.7
1999	227	27	11		265	1407.4	531.1
2000	639	481	205	396	1721	3771.8	219.2
2001	280	574	674	950	2478	4314.4	174.1
2002	1320	301	437	347	2405	3638.3	151.3
2003	1046	1111	1948	1525	5630	3865.6	68.7
2004	1880	1011	425	228	3544	3782.3	106.7
2005	494	644	1117	1287	3542	3557.6	100.4
2006	1109	806	1225	1197	4337	3029.4	69.9
2007	719	1020	1138	1030	3907	3989.8	102.1
2008	858	1225	1213	1173	4469	5443.5	121.8
2009	947	1407	1684	2222	6260	5952.9	95.1
2010	1335	1235	1856	1103	5529	5356.4	96.9
2011	735	1867	1555	1412	5569	4597.9	82.6
2012	767	1368	914	837	3886	2759.0	71.0
2013	1070	1390	1143	834	4437	950.8	21.4

Table A5. Total Gulf of Maine Atlantic cod (*Gadus morhua*) commercial landings-at-age (numbers) from 1982 to 2013.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1982		27,609	1,335,509	1,634,173	1,116,072	619,571	51,241	69,146	59,375	43,415	32,683	6,285	898				
1983			833,083	2,413,843	1,067,910	627,331	407,393	44,212	57,669	25,845	12,747	3,800	3,515	1,719	2,599		
1984		2,782	425,538	1,227,232	1,504,575	396,710	195,918	96,402	9,105	16,794	14,229	11,957	2,335	3,863	1,235		
1985			387,614	1,440,985	1,002,193	615,000	123,315	73,198	32,430	3,962	10,619	2,438	4,573	1,583	470		
1986			85,363	2,187,322	818,717	239,742	161,736	38,700	27,497	19,813	4,745	1,497	3,940	2,434	306		
1987		442	193,735	627,766	1,116,907	267,706	64,579	45,981	5,481	8,410	9,270	182	607		2,129		
1988			167,468	1,356,369	907,960	400,942	58,792	21,864	20,247	3,257	2,438	1,213			606		
1989			322,130	1,486,592	1,354,890	451,857	70,570	58,876	7,931	2,238	9,000	3,945		1,127	1,127		
1990			210,618	3,403,626	2,227,578	452,797	151,887	25,246	24,675	7,680	16,034	11,764	2,353	3,597			
1991			198,915	609,915	4,543,525	904,421	138,556	42,961	25,983	7,877	4,698	2,571					
1992			302,552	527,720	432,280	1,969,905	213,021	77,420	5,837	4,488	1,042						
1993			25,866	1,543,228	729,548	92,745	464,198	37,780	11,264								
1994			29,014	1,055,313	1,170,244	240,940	63,586	69,917	28,114	6,108	384	1,008					
1995			183,724	938,703	1,056,404	207,195	28,494	6,521	17,992	580	2,228						
1996			55,763	507,349	1,763,068	375,559	35,144	3,903	413	845							
1997			77,455	434,378	435,036	800,750	67,415	5,368	2,080	393	636						
1998			87,919	391,916	544,744	139,369	187,088	27,507	4,853	1,495	762						
1999			2,858	179,688	191,438	66,127	23,995	22,398	7,504	1,035							
2000			102,341	258,469	501,545	124,105	66,295	9,007	6,465								
2001			43,737	471,763	326,442	206,475	65,902	38,490	5,509	8,803	1,006						
2002			1,439	111,287	433,957	170,415	102,971	41,667	12,019	3,750	4,055	434	80		40		
2003			8,113	47,543	198,476	380,859	120,697	52,001	19,769	9,173	4,250	2,812	472				
2004			492	142,749	130,172	220,142	170,502	52,305	26,442	13,941	6,789	1,414	620				
2005			1,217	37,890	423,154	64,419	178,040	83,220	21,459	12,366	5,056	3,125	1,817	500			
2006			777	115,306	181,958	300,653	21,412	62,692	29,111	10,477	5,994	2,537	1,242	953	180		
2007			5,209	95,694	629,852	99,105	178,429	5,952	15,582	7,698	3,753	1,468	1,323	1,174	126	345	
2008			4,142	283,069	465,757	600,316	53,944	82,494	2,490	6,652	3,224	986	473	367	234	104	21
2009			2,700	283,610	718,934	333,800	199,827	16,653	20,518	857	2,311	1,072	952	224	127	61	49
2010			1,683	121,449	578,192	463,641	114,076	59,845	8,069	2,947	446	476	162	112	17	28	
2011			534	97,964	296,737	396,070	256,786	26,149	29,090	4,906	1,177	196	538	68	178		
2012			10,688	128,853	288,100	174,639	109,225	53,408	7,150	2,173	1,149	31		93			
2013		142	11,438	91,528	74,399	72,869	14,160	10,023	6,344	591	197	116					

Table A6. Coefficients of variation (CV) associated with the estimates of Gulf of Maine Atlantic cod (*Gadus morhua*) commercial landings numbers-at-age from 1984 to 2013 (CVs greater than 0.3 are shaded grey). *Note that prior to 1984 CVs could not be calculated.*

Year	Age0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16
1984		0.7443	0.12	0.04	0.02	0.04	0.06	0.06	0.17	0.16	0.22	0.20	0.39	0.29	0.69		
1985			0.08	0.06	0.04	0.03	0.05	0.05	0.10	0.25	0.14	0.27	0.35	0.48	0.76		
1986			0.18	0.05	0.04	0.06	0.08	0.14	0.13	0.20	0.44	0.56	0.37	0.65	0.89		
1987		1.3501	0.19	0.07	0.04	0.07	0.09	0.15	0.29	0.28	0.43	0.90	0.44		0.68		
1988			0.29	0.06	0.05	0.06	0.09	0.15	0.24	0.48	0.81	0.81			1.32		
1989			0.38	0.08	0.09	0.07	0.14	0.24	0.33	0.56	0.23	0.34		0.68	0.69		
1990			0.26	0.07	0.08	0.13	0.24	0.47	0.36	0.41	0.26	0.28	0.67	0.70			
1991			0.23	0.15	0.04	0.11	0.12	0.23	0.31	0.27	1.02	0.64					
1992			0.18	0.20	0.13	0.06	0.11	0.18	0.62	0.56	0.88						
1993			0.89	0.09	0.18	0.29	0.11	0.34	0.41								
1994			0.49	0.10	0.07	0.27	0.25	0.21	0.22	0.64	1.02	0.89					
1995			0.25	0.12	0.09	0.10	0.35	0.23	0.21	1.05	0.61						
1996			0.27	0.10	0.04	0.14	0.20	0.28	0.95	0.69							
1997			0.20	0.09	0.07	0.06	0.14	0.32	0.27	0.62	0.60						
1998			0.16	0.11	0.07	0.15	0.15	0.27	0.37	0.49	0.99						
1999				0.19	0.12	0.31	0.36	0.23	0.17	0.58							
2000			0.14	0.08	0.06	0.12	0.23	0.49	0.55								
2001			0.24	0.06	0.07	0.08	0.11	0.14	0.30	0.28	0.59						
2002			1.11	0.22	0.05	0.09	0.07	0.11	0.15	0.29	0.26	0.48	1.21		1.38		
2003			0.35	0.17	0.05	0.03	0.06	0.07	0.10	0.17	0.19	0.23	0.46				
2004			1.38	0.11	0.07	0.07	0.06	0.09	0.13	0.21	0.23	0.49	0.75				
2005			0.66	0.15	0.05	0.08	0.09	0.08	0.12	0.12	0.15	0.21	0.26	0.42			
2006			1.02	0.17	0.06	0.04	0.14	0.09	0.09	0.14	0.11	0.17	0.22	0.27	0.56		
2007			0.49	0.13	0.04	0.08	0.10	0.27	0.19	0.12	0.15	0.25	0.23	0.27	0.69	0.46	
2008			0.72	0.10	0.05	0.05	0.13	0.08	0.39	0.16	0.17	0.29	0.38	0.44	0.56	0.80	1.43
2009			0.52	0.10	0.05	0.09	0.07	0.18	0.12	0.25	0.17	0.26	0.26	0.40	0.59	0.90	1.01
2010			0.50	0.12	0.04	0.04	0.08	0.10	0.13	0.16	0.38	0.34	0.66	0.67	1.38	1.42	
2011			0.28	0.04	0.02	0.01	0.01	0.02	0.02	0.07	0.14	0.34	0.26	0.72	0.45		
2012			0.35	0.09	0.05	0.07	0.07	0.10	0.29	0.35	0.23	0.95	0.62				
2013		1.3136	0.17	0.05	0.06	0.06	0.11	0.10	0.14	0.24	0.35	0.41					
Average		1.05	0.43	0.11	0.06	0.10	0.13	0.19	0.27	0.35	0.43	0.42	0.46	0.50	0.82	0.90	1.22

Table A7. Mean weights-at-age (kg) of commercially landed Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1982		0.831	1.177	1.669	2.790	5.006	7.097	9.580	9.945	12.789	19.365	16.480	22.443				
1983			1.172	1.621	2.428	3.812	6.058	5.982	10.480	11.548	11.138	18.890	12.669	24.552	22.224		
1984		0.569	1.179	1.656	2.679	3.568	5.563	8.541	10.290	13.711	14.485	14.318	15.430	17.886	19.285		
1985			1.312	1.740	2.820	4.528	5.610	8.436	11.238	12.479	14.280	13.394	16.112	16.739	22.012		
1986			1.392	1.819	2.905	4.691	6.272	7.994	9.826	13.592	13.496	15.888	15.808	20.232	16.834		
1987		0.998	1.369	1.719	3.252	4.805	6.912	9.318	10.769	14.810	16.101	13.418	8.066		22.379		
1988			1.293	1.943	2.448	5.282	5.315	6.374	9.951	10.434	17.787	9.857			21.886		
1989			1.314	1.763	3.055	4.242	5.943	9.379	13.425	16.500	20.410	22.606		27.911	27.896		
1990			1.247	1.660	2.238	4.380	7.816	11.229	12.270	15.999	16.344	22.690	23.134	22.138			
1991			1.489	1.834	2.412	4.031	7.164	9.689	12.261	15.093	6.203	24.937					
1992			1.608	1.941	2.899	3.070	5.699	10.984	10.766	13.418	19.072						
1993			1.356	1.930	2.350	4.595	5.802	9.649	13.673								
1994			1.434	1.955	3.186	3.349	6.350	7.787	12.422	10.012	22.008	22.643					
1995			1.588	1.774	2.838	5.187	7.054	11.466	13.223	19.756	23.143						
1996			1.746	2.258	2.337	3.532	7.523	11.759	14.795	16.331							
1997			1.846	2.291	3.093	3.162	4.829	9.027	12.177	15.625	17.749						
1998			1.396	2.020	2.726	4.025	4.376	7.235	12.111	17.500	15.060						
1999			1.545	1.741	2.539	3.390	5.049	7.563	10.220	12.279							
2000			1.736	2.608	3.635	4.678	6.158	5.600	8.939								
2001			1.937	2.556	3.400	5.036	6.544	7.684	9.213	8.945	17.660						
2002			1.326	2.706	3.378	4.269	6.300	7.072	8.965	10.167	10.786	15.353	17.249		18.746		
2003			1.871	2.475	3.279	4.321	5.544	7.584	8.892	10.909	12.121	13.709	14.362				
2004			1.648	2.689	3.686	4.261	5.976	7.590	9.902	12.654	14.059	11.423	22.553				
2005			1.926	2.274	3.118	4.584	4.793	6.447	8.066	11.054	13.942	14.901	15.362	19.605			
2006			2.671	2.540	3.437	3.877	4.905	5.673	7.605	9.709	12.724	16.000	15.761	20.480	20.326		
2007			2.090	2.616	3.317	4.053	5.014	6.518	7.182	10.140	12.199	13.344	14.213	17.126	21.784	21.757	
2008			1.848	2.768	3.145	3.811	4.777	6.036	6.106	8.583	11.258	13.800	16.189	19.251	19.918	18.735	25.984
2009			1.939	2.766	3.532	3.972	4.775	6.007	8.367	11.208	10.805	12.934	15.971	15.803	22.452	22.459	22.812
2010			2.228	2.731	3.528	4.268	4.874	5.550	8.478	10.152	11.016	13.209	12.519	16.891	20.103	16.834	
2011			1.746	2.724	3.389	4.094	4.988	5.934	6.076	11.750	12.190	17.376	17.827	23.845	19.502		
2012			1.903	2.927	3.146	3.593	4.300	5.337	5.407	7.951	12.770	21.458		18.259			
2013		1.295	1.615	2.636	3.182	3.856	4.184	5.782	7.227	10.357	10.854	15.982					

Table A8. Total number of Gulf of Maine trips (statistical areas 464, 465, 467, 511-515) observed from 1989 to 2013, summarized by gear type. ***The 2010-13 numbers include trips observed by both at-sea monitors and observers.***

Year	Longline	Otter trawl		Shrimp trawl	Sink Gillnet		Total
		Small mesh (< 5.5")	Large mesh (>= 5.5")		Large mesh (5.5" - 7.99")	Extra large mesh (>= 8.0")	
1989		23	44	40	84		191
1990		8	26	31	120		185
1991	2	29	53	52	801		937
1992	9	15	45	82	896		1047
1993	2	6	17	81	560		666
1994			9	77	82	7	175
1995		30	29	73	62	14	208
1996		40	19	35	39	10	143
1997		3	7	16	31	5	62
1998			7		78	6	91
1999		11	25		70	8	114
2000			122		70	19	211
2001		4	136	3	39	21	203
2002		34	199		62	25	320
2003	14	19	278	15	254	95	675
2004	8	68	321	12	587	340	1336
2005	58	69	534	17	505	251	1434
2006	36	24	209	20	109	35	433
2007	36	16	234	14	92	46	438
2008	20	12	260	19	130	49	490
2009	35	22	428	12	271	30	798
2010	52	30	685	15	1080	379	2241
2011	80	25	1098	1	1382	264	2850
2012	113	31	1177	19	1166	119	2625
2013	33	63	670	24	495	96	1381

Table A9. Estimates of total Gulf of Maine Atlantic cod (*Gadus morhua*) commercial discards (mt) by gear from 1982 to 2013 by gear. Discards from 1982 to 1988 were estimated using hindcast procedures and discards from 1989 to 2013 were estimated from observer data. See NEFSC (2013) for a full description of the methodology. *Discard amounts reflect application of mortality assumptions adopted for the SAW/SARC 55 assessment (NEFSC 2013; commercial longline = 33%, commercial trawl = 75%, commercial gillnet = 80%).*

Year	Longline	Otter trawl		Shrimp trawl	Sink Gillnet		Total
		Small mesh (< 5.5")	Large mesh (>= 5.5")		Large mesh (5.5" - 7.99")	Extra large mesh (>= 8.0")	
1982			618.0	100.8	86.7		805.4
1983			633.1	112.1	83.9		829.1
1984			603.0	160.0	96.0		858.9
1985			660.4	217.9	84.7		962.9
1986			597.4	266.4	100.4		964.2
1987			541.9	242.1	100.1		884.0
1988			428.4	151.7	102.8		682.9
1989		4.2	474.1	179.5	129.0		786.9
1990		0.6	1,097.3	287.5	175.2		1,560.6
1991	0.1	0.6	434.7	143.7	84.8		663.9
1992	2.6	0.0	545.1	34.2	86.6		668.6
1993	93.0	0.0	259.6	4.4	122.9		479.8
1994			114.7	5.3	84.1	3.5	207.5
1995		5.8	106.8	2.8	103.8	16.3	235.4
1996		2.3	17.6	2.1	116.2	19.0	157.2
1997		11.6	19.5	3.3	47.2	5.5	87.1
1998		0.0	8.1		66.0	4.4	78.5
1999		8.2	578.5		428.8	6.5	1,021.9
2000			552.3		379.0	14.8	946.1
2001		0.1	611.1	0.0	890.8	43.4	1,545.4
2002		11.5	608.0		662.9	46.7	1,329.1
2003	21.9	15.4	387.6	1.8	257.4	56.8	741.0
2004	2.6	2.0	372.7	0.7	185.4	67.7	631.1
2005	40.9	2.7	116.2	0.8	87.6	21.3	269.5
2006	15.7	1.8	236.4	0.2	75.5	12.7	342.3
2007	22.2	1.4	71.8	0.6	66.9	15.4	178.4
2008	19.3	4.3	240.2	0.1	67.9	17.4	349.2
2009	6.3	1.4	503.9	0.1	210.6	29.9	752.3
2010	3.8	4.4	111.7	0.2	42.1	8.5	170.8
2011	10.5	3.2	54.5	0.0	27.6	3.0	98.8
2012	12.1	1.9	52.9	0.0	25.6	0.8	93.4
2013	10.7	0.5	30.8	0.0	8.3	1.1	51.5

Table A10. Coefficients of variation (CV) for the Gulf of Maine Atlantic cod (*Gadus morhua*) commercial discard (mt) estimates from 1989 to 2013 by gear; CVs greater than 0.3 are shaded in grey. *CVs are not available for hindcasted discards (pre-1989).*

Year	Longline	Otter trawl		Shrimp trawl	Sink Gillnet		Total
		Small mesh (< 5.5")	Large mesh (>= 5.5")		Large mesh (5.5" - 7.99")	Extra large mesh (>= 8.0")	
1989		**0.67**	**0.34**	0.25	0.29		0.22
1990		**0.79**	**0.37**	**0.42**	0.23		0.28
1991	**0.40**	**0.60**	**0.37**	**0.32**	0.10		0.26
1992	**0.64**	**3.72**	**0.33**	0.24	0.07		0.27
1993	0.20		**0.44**	0.13	0.09		0.22
1994			**0.63**	0.15	**0.32**	**0.75**	**0.38**
1995		0.24	**0.59**	0.24	0.26	**0.45**	**0.31**
1996		**2.84**	**0.91**	**0.34**	0.30	0.28	0.25
1997		0.25	**0.44**	**0.41**	**0.42**	**0.85**	0.25
1998			**0.55**		0.28	**0.95**	0.25
1999		**0.62**	**0.56**		**0.37**	**0.51**	**0.36**
2000			0.28		0.27	**0.31**	0.20
2001		**1.84**	0.27		**0.52**	**0.58**	**0.31**
2002		**0.55**	**0.34**		0.24	**0.59**	0.20
2003	**0.30**	**0.72**	0.29	**0.42**	0.14	0.28	0.16
2004	**0.48**	**0.44**	**0.34**	**0.37**	0.13	0.12	0.22
2005	0.24	0.27	0.19	**0.38**	0.13	0.12	0.11
2006	0.29	0.27	**0.39**	**0.44**	**0.38**	**0.32**	0.28
2007	0.17	**0.43**	0.22	**0.70**	0.29	**0.31**	0.13
2008	**0.42**	**0.37**	0.21	**0.55**	0.18	**0.49**	0.16
2009	0.17	0.28	0.14	**0.64**	0.19	**0.49**	0.11
2010	**0.33**	0.28	0.19	**0.90**	0.11	0.17	0.13
2011	0.18	**0.41**	0.09		0.04	0.07	0.06
2012	0.20	**0.44**	0.08	**1.02**	0.04	0.06	0.07
2013	**0.62**	**0.63**	0.27	**0.95**	0.07	0.21	0.26

Table A11. Length sampling of Gulf of Maine Atlantic cod (*Gadus morhua*) commercial discards from 1989 to 2013 by gear type and semester. Sampling intensity is expressed as metric tons landings per 100 lengths sampled (*200 metric tons per 100 lengths is an unofficial NAFO/ICNAF standard*). Colors denote specific gear/mesh sizes; in all years except 2003-2005, 2007/08 and 2010/11 the length frequency distributions from large mesh gillnet were applied to extra large mesh gillnet due to insufficient sampling. A general criterion of 50 lengths/block was used to determine sufficiency.

Year	Longline		Otter trawl - small mesh		Otter trawl - large mesh		Shrimp trawl		Gillnet - large mesh		Gillnet - extra large mesh		Total	Total discards (mt)	mt/100 lengths
	Semi 1	Semi 2	Semi 1	Semi 2	Semi 1	Semi 2	Semi 1	Semi 2	Semi 1	Semi 2	Semi 1	Semi 2			
1989			125	14	542	1053	2011	77		104			3926	1101.1	28.0
1990			**		587	818	607	31	138	3			2184	2198.2	100.6
1991	*		**		706	124	397		65	30			1322	933.5	70.6
1992	*		**		924	924	401	10	78	130			2467	943.8	38.3
1993	48		**		68	866	591		90	223			1886	812.4	43.1
1994			**		194		563	40	274	112		7	1190	280.8	23.6
1995				69	225	473	377	3	60	147	20	3	1377	314.9	22.9
1996			52	19	15	73	44	21	109	31	16	20	400	200.4	50.1
1997			7***		104	1	17*****		34	11	1	2	153	115.0	75.2
1998			***		5****				43	40	9	3	95	99.5	104.8
1999			6***			220			130	1156		14	1520	1382.1	90.9
2000			***		248	85			125	157	6	6	627	1281.3	204.3
2001			***		61	647			223	144	3	4	1082	2040.9	188.6
2002				192	104	1162			412	845	1	39	2755	1772.0	64.3
2003	718		173	131	1109	234	192		603	1352	38	205	4755	1037.6	21.8
2004	197		103	519	385	771	76		1165	1524	27	536	5303	860.6	16.2
2005	2283	147	180	183	986	2939	70		190	663	47	104	7792	431.0	5.5
2006	880	3	43	9	1899	339	96		44	59	6	15	3393	498.4	14.7
2007	817	327	1	62	1172	1103	12******		91	310	53	164	4100	275.7	6.7
2008	958			18	2316	1639	42******		142	73	72	26	5244	514.5	9.8
2009	552	187		22	2219	1744	2******		502	112	7	15	5360	1041.8	19.4
2010	239	57	4	51	716	2672	5******		289	903	30	94	5055	241.1	4.8
2011	1322	107		27	2522	3612			792	694	33	41	9150	152.6	1.7
2012	1188	278	9		2607	2509	3*******		897	623	10	11	8135	148.0	1.8
2013	1266		32	21	1523	726	*******		111	195	3	6	3883	89.0	2.3

**Borrowed from 1993 LF*
***Used 1989-1995 aggregate LF*
****Used 1996-2002 aggregate LF*
*****Borrowed from 1997 LF*
******Used 1996-1997 aggregate LF*
*******Used 2007 - 2010 aggregate LF*
********Used 2007 - 2013 aggregate LF*

Table A12. Total Gulf of Maine Atlantic cod (*Gadus morhua*) commercial discards-at-age (numbers) from 1982 to 2013. *These estimates include gear-specific assumptions of discard survival.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1982	581	347,720	1,156,034	224,521	50,895	0	0	0	0	0	0	0	0	0	0	0	0
1983	13,645	562,544	1,281,940	158,839	5,416	0	0	0	0	0	0	0	0	0	0	0	0
1984	18,275	347,694	1,445,433	219,644	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	67,101	459,681	1,162,717	516,585	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	17,767	731,053	1,522,658	208,195	48,007	0	0	0	0	0	0	0	0	0	0	0	0
1987	100,702	252,248	1,375,956	406,263	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	3,446	405,259	1,149,396	275,330	23,306	0	0	0	0	0	0	0	0	0	0	0	0
1989	43	157,339	733,450	415,475	51,442	5,129	1,380	502	109	0	0	0	0	0	0	0	0
1990	0	61,442	539,508	1,619,321	185,562	1,188	216	0	0	0	0	0	0	0	0	0	0
1991	3,251	115,661	244,750	156,398	273,359	23,658	945	211	0	494	22	0	0	0	0	0	0
1992	23,803	364,755	481,485	278,021	32,164	91,688	2,805	119	14	0	0	0	0	0	0	0	0
1993	26,570	100,225	345,799	212,563	62,392	47	682	187	0	0	0	0	0	0	0	0	0
1994	11,734	119,195	93,081	140,124	14,606	816	234	270	0	0	0	0	0	0	0	0	0
1995	11,572	75,059	57,584	104,772	42,720	3,914	413	0	0	0	0	0	0	0	0	0	0
1996	22,067	31,719	22,411	24,451	38,147	6,928	657	102	78	542	0	0	0	0	0	0	0
1997	1,472	66,116	33,817	27,941	5,256	13,811	766	120	0	0	0	0	0	0	0	0	0
1998	699	2,565	36,073	20,996	13,651	1,615	1,536	82	0	0	0	0	0	0	0	0	0
1999	63	58,620	35,442	77,449	78,134	64,863	19,741	22,472	3,779	32	0	0	0	0	0	0	0
2000	0	10,977	192,879	122,257	137,216	26,040	8,080	1,471	315	0	0	0	0	0	0	0	0
2001	0	584	166,381	181,295	117,448	89,585	23,098	9,463	1,433	1,304	0	0	0	0	0	0	0
2002	0	10,379	26,625	95,299	150,797	58,039	36,422	15,103	9,627	3,784	3,221	270	220	0	0	0	0
2003	22,873	30,227	60,078	48,552	131,760	95,818	18,452	5,589	1,985	819	315	204	15	0	0	0	0
2004	187	130,674	71,594	234,041	42,241	41,615	19,027	4,267	1,900	569	231	88	11	0	0	0	0
2005	1,487	19,746	72,822	27,925	88,613	2,854	7,378	2,689	588	435	156	176	80	43	0	0	0
2006	204	10,521	29,696	159,504	38,366	53,974	2,405	2,150	1,902	93	34	5	0	1	0	0	0
2007	407	10,720	49,447	57,421	49,909	4,291	2,782	49	53	6	0	2	0	0	0	0	0
2008	305	7,598	58,021	104,763	59,668	40,918	1,629	1,361	75	17	27	26	0	0	0	0	0
2009	81	5,791	52,840	167,603	143,740	56,239	26,856	734	1,259	13	33	7	0	8	0	0	0
2010	213	4,607	23,503	52,319	27,322	15,926	3,289	989	20	2	0	0	0	0	0	0	0
2011	27	1,612	13,351	31,934	28,579	6,662	1,533	153	29	87	0	0	0	0	0	0	0
2012	5	2,866	23,763	32,839	19,192	8,527	999	291	1	0	0	0	0	0	0	0	0
2013	119	1,930	25,249	15,987	8,015	3,454	427	21	1	0	0	0	0	0	0	0	0

Table A13. Mean weights-at-age (kg) of commercially discarded Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1982	0.000	0.315	0.500	0.608	0.648												
1983	0.024	0.218	0.509	0.649	0.752												
1984	0.001	0.225	0.485	0.610													
1985	0.039	0.194	0.541	0.589													
1986	0.005	0.274	0.439	0.621	0.573												
1987	0.004	0.143	0.492	0.559													
1988	0.003	0.121	0.442	0.554	0.615												
1989	0.046	0.224	0.490	0.751	1.751	4.112	5.534	9.336	6.408								
1990		0.195	0.645	0.703	0.846	4.340	4.564										
1991	0.014	0.238	0.859	0.917	0.993	1.401	6.746	8.389		18.191	3.705						
1992	0.023	0.053	0.680	0.773	1.082	1.154	1.614	5.239	2.425								
1993	0.021	0.073	0.684	0.944	0.926	1.953	4.309	7.342									
1994	0.022	0.049	0.629	0.827	1.798	3.872	12.083	9.439									
1995	0.027	0.093	0.809	0.925	1.637	4.928	4.682										
1996	0.033	0.067	0.676	1.126	1.840	3.752	6.768	11.559	12.656	17.406							
1997	0.017	0.058	0.590	0.928	1.984	1.785	4.381	8.657									
1998	0.007	0.200	0.603	1.093	1.686	3.316	3.287	3.285									
1999	0.052	0.201	0.595	1.940	3.353	4.626	6.586	6.605	9.634	12.279							
2000		0.292	0.962	1.843	3.041	3.882	4.881	4.279	6.121								
2001		0.316	0.669	2.023	3.777	4.898	5.908	6.594	7.159	8.790							
2002		0.203	0.923	1.415	2.987	4.222	6.258	7.030	9.453	12.322	10.912	10.519	14.222				
2003	0.038	0.133	0.804	1.364	1.672	2.772	4.085	6.911	9.868	8.622	11.658	10.100	12.774				
2004	0.025	0.106	0.455	1.128	1.879	2.800	4.834	6.755	8.763	11.588	11.820	10.579	11.694				
2005	0.027	0.109	0.564	1.170	1.400	3.246	3.573	5.707	7.370	10.673	15.830	16.405	17.950	23.098			
2006	0.069	0.276	0.665	1.066	1.494	1.604	1.871	3.857	2.822	7.902	8.238	13.434		13.434			
2007	0.024	0.227	0.658	1.063	1.394	1.710	2.171	4.447	5.197	6.529		7.736					
2008	0.078	0.203	0.770	1.273	1.572	1.741	3.047	6.283	6.021	5.514	10.341	10.660					
2009	0.026	0.356	0.913	1.515	2.010	2.109	2.402	3.970	3.288	8.250	8.733	7.259		10.510			
2010	0.023	0.251	1.047	1.251	1.743	1.912	1.962	2.184	4.322	8.210							
2011	0.122	0.361	0.875	1.181	1.303	1.473	1.592	1.669	2.623	16.409							
2012	0.011	0.376	0.910	1.126	1.284	1.303	1.489	1.724	3.881								
2013	0.030	0.511	0.794	1.123	1.266	1.353	1.434	1.669	2.100								

Table A14. Estimates of Gulf of Maine Atlantic cod (*Gadus morhua*) recreational catch in numbers (000's) and weight (mt) from 1981 to 2013. Recreational releases are shown using both the 100% discard mortality (grey) and the 30% mortality assumptions applied in the assessment. *Coefficients of variation (CVs) on the 2011-2013 harvest estimates ranged from 0.08-0.25 and 0.07-0.19 for the releases.*

Year	Numbers (000s)				Biomass (mt)				Released/harvest ratio
	Harvest (AB1)	Released (B2) w/ 100% discard mortality	Released (B2) w/ 30% discard mortality	Total catch w/ 30% discard mortality	Harvest (AB1)	Released (B2) w/ 100% discard mortality	Released (B2) w/ 30% discard mortality	Total catch w/ 30% discard mortality	
1981	2011.2	145.1	43.5	2054.7	4111.5	62.8	18.8	4130.4	0.07
1982	1368.7	71.6	21.5	1390.2	2816.7	27.2	8.1	2824.9	0.05
1983	937.1	174.2	52.2	989.4	1772.8	58.6	17.6	1790.4	0.19
1984	678.9	148.7	44.6	723.6	1266.8	55.3	16.6	1283.4	0.22
1985	1212.5	150.9	45.3	1257.8	2765.9	56.2	16.9	2782.7	0.12
1986	734.0	91.9	27.6	761.6	1928.4	33.7	10.1	1938.5	0.13
1987	1504.5	428.5	128.6	1633.1	3547.2	160.0	48.0	3595.2	0.28
1988	943.2	133.3	40.0	983.2	1688.5	45.2	13.5	1702.1	0.14
1989	893.2	432.6	129.8	1023.0	1957.2	253.6	76.1	2033.2	0.48
1990	930.9	357.6	107.3	1038.2	2246.7	222.4	66.7	2313.4	0.38
1991	1023.1	310.3	93.1	1116.1	2287.2	226.7	68.0	2355.3	0.30
1992	238.4	180.8	54.2	292.7	623.6	118.2	35.5	659.0	0.76
1993	568.3	568.0	170.4	738.7	1011.9	339.8	101.9	1113.9	1.00
1994	392.9	543.6	163.1	556.0	721.7	335.3	100.6	822.3	1.38
1995	378.6	516.2	154.8	533.5	627.2	320.5	96.2	723.4	1.36
1996	260.0	340.8	102.2	362.3	498.6	270.1	81.0	579.7	1.31
1997	105.0	227.0	68.1	173.1	236.3	195.9	58.8	295.1	2.16
1998	144.2	289.6	86.9	231.1	353.1	240.8	72.2	425.3	2.01
1999	184.7	359.7	107.9	292.6	577.2	238.8	71.7	648.8	1.95
2000	388.5	696.2	208.8	597.4	967.1	458.7	137.6	1104.7	1.79
2001	755.6	992.0	297.6	1053.2	1967.6	758.3	227.5	2195.0	1.31
2002	409.1	823.5	247.1	656.1	1254.8	956.2	286.9	1541.7	2.01
2003	454.9	837.8	251.3	706.3	1607.7	941.4	282.4	1890.1	1.84
2004	379.4	736.8	221.0	600.5	1150.9	671.2	201.4	1352.2	1.94
2005	446.9	1038.1	311.4	758.3	1346.9	891.0	267.3	1614.2	2.32
2006	188.7	708.4	212.5	401.2	702.3	646.7	194.0	896.3	3.75
2007	303.5	964.4	289.3	592.9	1042.2	1056.2	316.9	1359.1	3.18
2008	382.6	952.1	285.6	668.2	1267.2	1051.2	315.4	1582.6	2.49
2009	386.9	826.0	247.8	634.7	1357.1	974.8	292.4	1649.6	2.13
2010	503.9	1049.4	314.8	818.7	1758.2	1281.6	384.5	2142.6	2.08
2011	516.0	892.4	267.7	783.8	1799.1	1114.1	334.2	2133.3	1.73
2012	320.0	470.7	141.2	461.2	571.4	319.8	96.0	667.4	1.47
2013	324.7	582.2	174.7	499.4	587.1	419.9	126.0	713.1	1.79

Table A15. Length sampling intensity of recreationally harvested (type A and B1) Gulf of Maine Atlantic cod (*Gadus morhua*) by semester and year as estimated by the Marine Recreational Information Program from 1981 to 2013. Sampling intensity is expressed as metric tons of landings per 100 lengths sampled (*200 metric tons per 100 lengths is an unofficial NAFO/ICNAF standard*).

Year	Semester		Total	AB1 estimated numbers (000s)	AB1 Landings (mt)	Lengths per 1000 fish	mt per 100 lengths
	1	2					
1981	355	366	721	2,011	4,112	0.4	570.3
1982	320	276	596	1,369	2,817	0.4	472.6
1983	609	560	1,169	937	1,773	1.2	151.7
1984	394	391	785	679	1,267	1.2	161.4
1985	272	155	427	1,213	2,766	0.4	647.7
1986	77	90	167	734	1,928	0.2	1154.8
1987	167	367	534	1,505	3,547	0.4	664.3
1988	325	213	538	943	1,689	0.6	313.9
1989	208	352	560	893	1,957	0.6	349.5
1990	160	210	370	931	2,247	0.4	607.2
1991	377	83	460	1,023	2,287	0.4	497.2
1992	710	268	978	238	624	4.1	63.8
1993	136	200	336	568	1,012	0.6	301.2
1994	333	485	818	393	722	2.1	88.2
1995	663	434	1,097	379	627	2.9	57.2
1996	585	515	1,100	260	499	4.2	45.3
1997	190	392	582	105	236	5.5	40.6
1998	447	215	662	144	353	4.6	53.3
1999	111	117	228	185	577	1.2	253.1
2000	70	77	147	389	967	0.4	657.9
2001	124	121	245	756	1,968	0.3	803.1
2002	181	196	377	409	1,255	0.9	332.8
2003	361	322	683	455	1,608	1.5	235.4
2004	422	473	895	379	1,151	2.4	128.6
2005	391	382	773	447	1,347	1.7	174.2
2006	681	155	836	189	702	4.4	84.0
2007	479	220	699	304	1,042	2.3	149.1
2008	590	231	821	383	1,267	2.1	154.3
2009	852	488	1,340	387	1,357	3.5	101.3
2010	621	508	1,129	504	1,758	2.2	155.7
2011	711	496	1,207	516	1,799	2.3	149.1
2012	1,098	1,361	2,459	320	571	7.7	23.2
2013	1,514	1,160	2,674	325	587	8.2	22.0

Table A16. Length sampling intensity of recreationally discarded (type B2) Gulf of Maine Atlantic cod (*Gadus morhua*) by semester and year as estimated by the Marine Recreational Information Program from 2005 to 2013. Length samples of recreationally discarded (i9 samples) Atlantic cod were unavailable prior to 2005. Sampling intensity is expressed as metric tons landings per 100 lengths sampled (*200 metric tons per 100 lengths is an unofficial NAFO/ICNAF standard*).

Year	Semester		Total	B2 releases (000s)	B2 releases (mt)	Lengths per thousand fish	Metric tons per 100 lengths
	1	2					
2005	577	624	1,201	1,038	891	1.2	208.1
2006	952	599	1,551	708	647	2.2	162.9
2007	728	846	1,574	964	1,056	1.6	216.2
2008	1,258	709	1,967	952	1,051	2.1	156.4
2009	765	889	1,654	826	975	2.0	216.2
2010	715	1,024	1,739	1,049	1,282	1.7	243.2
2011	493	937	1,430	892	1,114	1.6	290.1
2012	468	948	1,416	471	320	3.0	302.6
2013	795	595	1,390	582	420	2.4	174.8

Table A17. Total Gulf of Maine Atlantic cod (*Gadus morhua*) recreational landings-at-age (numbers) from 1982 to 2013.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1981	0	159,922	623,992	622,091	426,564	69,951	42,612	7,392	29,365	0	25,105	0	4,184	0	0	0	0
1982	765	67,908	420,464	427,446	263,437	129,184	14,639	24,905	13,178	3,904	574	0	2,296	0	0	0	0
1983	0	14,924	315,694	339,632	128,267	76,679	45,287	5,810	4,873	1,777	1,390	802	2,004	0	0	0	0
1984	0	11,741	224,928	226,199	139,013	40,743	23,707	9,247	390	420	350	627	0	432	1,153	0	0
1985	0	35,163	368,684	438,416	149,622	123,096	38,047	33,994	15,929	2,206	5,509	316	1,005	532	0	0	0
1986	0	21,723	120,551	351,802	124,583	39,540	40,989	9,316	10,691	6,281	3,579	865	3,202	865	0	0	0
1987	0	16,878	348,751	517,856	457,592	77,647	24,836	35,051	8,978	8,452	6,339	1,878	282	0	0	0	0
1988	0	3,134	197,888	449,655	225,659	46,787	8,638	3,696	6,000	0	0	1,753	0	0	0	0	0
1989	0	3,619	116,660	436,314	242,898	64,122	15,197	10,911	1,329	2,127	0	0	0	0	0	0	0
1990	0	2,812	40,204	449,749	295,754	87,368	36,966	4,457	11,742	1,887	0	0	0	0	0	0	0
1991	0	3,614	35,323	152,702	701,569	106,170	11,169	12,368	0	0	143	0	0	0	0	0	0
1992	0	2,101	21,451	43,626	35,194	123,077	10,143	2,642	193	0	0	0	0	0	0	0	0
1993	0	1,913	42,807	343,796	133,450	10,536	32,237	3,594	0	0	0	0	0	0	0	0	0
1994	0	475	13,965	243,207	103,423	24,535	2,404	3,971	600	370	0	0	0	0	0	0	0
1995	0	25	35,494	187,086	144,820	9,965	1,024	0	192	0	0	0	0	0	0	0	0
1996	0	0	11,977	64,661	162,532	19,752	850	34	0	236	0	0	0	0	0	0	0
1997	0	78	5,075	31,836	21,300	42,823	3,631	35	192	0	0	0	0	0	0	0	0
1998	218	0	9,310	52,886	52,992	11,547	15,851	1,107	315	0	0	0	0	0	0	0	0
1999	0	552	5,301	53,525	61,018	39,039	9,650	14,515	1,105	0	0	0	0	0	0	0	0
2000	0	0	52,606	130,285	163,854	25,350	10,670	2,007	3,741	0	0	0	0	0	0	0	0
2001	0	0	42,329	386,498	214,243	84,322	17,177	9,279	1,320	464	0	0	0	0	0	0	0
2002	0	0	310	57,771	233,715	73,361	23,839	9,622	6,047	785	1,454	0	2,170	0	0	0	0
2003	0	0	4,884	37,189	149,359	188,046	41,113	18,104	7,470	5,073	1,170	1,724	817	0	0	0	0
2004	0	0	97	98,544	72,720	129,126	58,696	11,806	4,675	1,764	1,182	224	609	0	0	0	0
2005	0	0	3,181	47,690	280,723	19,902	57,931	23,160	6,401	4,575	1,601	830	649	251	0	0	0
2006	0	0	167	29,903	47,416	78,493	5,155	14,283	7,461	2,864	1,753	636	344	184	41	0	0
2007	0	0	1,762	35,777	186,312	25,702	42,350	1,937	3,598	2,781	1,394	737	392	595	96	109	0
2008	0	0	3,945	93,103	123,240	101,819	27,956	26,590	1,476	2,097	2,330	0	0	0	0	0	0
2009	0	0	1,529	74,035	162,755	66,702	66,208	3,325	8,426	210	1,685	931	914	192	0	0	0
2010	0	0	10,155	93,506	204,897	141,754	37,562	9,467	3,124	1,413	223	0	1,785	0	0	0	0
2011	0	0	3,419	88,254	176,415	150,699	77,558	8,261	9,161	1,523	394	143	95	107	21		0
2012	0	3,652	20,798	101,732	116,139	57,367	14,684	5,100	427	80	14	0	0	0	0	0	0
2013	364	1,393	55,263	137,151	83,571	37,625	6,767	2,096	483	9	1	2	0	0	0	0	0

Table A18. Mean weights-at-age (kg) of recreationally landed Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1981		0.341	0.995	1.524	2.915	4.715	5.645	5.863	8.359		12.339		18.100				
1982	0.022	0.372	0.848	1.401	2.209	5.362	6.955	9.732	8.990	11.008	11.547		21.416				
1983		0.378	0.791	1.398	2.401	3.772	6.032	6.745	8.393	9.627	15.175	19.306	19.182				
1984		0.372	0.775	1.365	2.668	4.005	5.349	6.559	6.583	8.955	11.743	13.474		17.780	27.103		
1985		0.346	0.752	1.281	2.810	5.310	6.771	8.645	11.257	11.854	12.252	8.049	9.297	8.332			
1986		0.375	0.668	1.589	2.770	5.308	7.418	8.584	11.185	11.839	14.266	14.560	22.376	14.560			
1987		0.243	0.900	1.472	2.696	4.196	8.162	10.978	11.301	12.673	13.141	13.835	8.332				
1988		0.170	0.787	1.528	2.188	4.550	4.414	5.123	10.614			10.175					
1989		0.539	0.989	1.500	2.700	4.579	6.191	8.715	7.616	17.137							
1990		0.132	0.916	1.439	2.261	4.965	7.351	8.502	10.658	13.166							
1991		0.180	1.088	1.499	2.025	3.388	6.933	13.033			3.838						
1992		0.106	1.360	1.715	2.541	2.923	4.437	9.324	2.516								
1993		0.184	0.805	1.566	1.827	2.890	3.791	11.707									
1994		0.136	1.169	1.514	2.262	2.270	5.374	5.751	18.165	2.156							
1995		0.509	1.432	1.514	1.769	3.381	2.479		4.244								
1996			1.483	1.809	1.863	2.502	9.632	8.622		13.434							
1997		0.307	1.626	1.924	2.389	2.396	2.964	6.038	11.932								
1998	0.010		1.600	2.071	2.435	3.491	3.179	4.591	12.220								
1999		0.290	1.296	1.943	2.951	3.687	5.490	5.561	7.637								
2000			1.561	1.961	2.718	3.199	5.103	5.023	10.277								
2001			1.709	2.199	2.659	3.732	5.019	6.259	10.560	5.813							
2002			1.275	2.135	2.581	3.048	5.265	6.429	7.919	8.984	10.569		21.420				
2003			1.954	2.237	2.525	3.225	4.822	8.064	9.802	11.167	11.115	15.401	21.534				
2004			1.545	2.045	2.612	2.829	3.911	5.747	9.387	12.100	13.609	13.256	20.155				
2005			1.510	1.968	2.374	3.566	3.904	6.089	7.852	9.766	13.574	14.627	16.347	17.544			
2006			2.321	2.270	2.969	3.301	4.683	5.470	8.339	10.105	12.466	15.021	15.090	18.390	17.774		
2007			2.226	2.503	2.965	3.535	4.418	5.147	7.863	11.709	12.713	14.426	14.231	16.520	15.964	19.820	
2008			1.922	2.746	2.910	3.415	2.747	5.124	10.004	12.290	18.942						
2009			2.197	2.506	3.066	3.518	4.444	6.371	8.034	9.777	10.005	12.269	18.736	19.782			
2010			2.563	2.728	3.151	3.771	4.115	7.441	9.409	9.584	9.850		15.000				
2011			1.798	2.474	3.032	3.707	4.577	5.274	5.624	12.022	16.019	18.353	14.407	19.306	13.835		
2012		0.160	1.256	1.486	1.878	2.020	2.734	3.349	3.605	7.285	9.417						
2013	0.057	0.576	1.249	1.797	1.967	2.216	2.257	2.690	4.303	8.819	6.017	7.240					

Table A19. Total Gulf of Maine Atlantic cod (*Gadus morhua*) recreational discards-at-age (numbers) from 1981 to 2011. *These estimates include assumptions of 30% discard survival.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1981	0	13,575	24,578	5,363	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	5,612	14,535	1,052	278	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	20,028	31,320	901	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	8,107	33,657	2,856	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	10,816	25,312	9,151	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	7,925	18,474	492	675	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	12,226	99,875	16,449	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	6,688	28,038	5,279	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	5,478	74,963	46,707	2,626	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	1,273	22,214	75,071	8,729	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	2,352	20,600	23,716	42,819	3,603	0	0	0	0	0	0	0	0	0	0	0
1992	0	3,446	24,659	18,197	2,446	5,287	198	0	0	0	0	0	0	0	0	0	0
1993	0	3,791	97,835	49,454	19,319	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	4,326	65,863	86,959	5,930	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	3,848	42,660	91,272	16,491	579	0	0	0	0	0	0	0	0	0	0	0
1996	0	5,817	21,418	31,232	40,139	3,642	0	0	0	0	0	0	0	0	0	0	0
1997	0	2,950	21,137	25,402	6,176	11,777	660	0	0	0	0	0	0	0	0	0	0
1998	0	3,376	37,760	26,503	17,554	289	1,398	0	0	0	0	0	0	0	0	0	0
1999	0	14,776	47,252	37,178	6,006	2,315	313	84	0	0	0	0	0	0	0	0	0
2000	0	13,781	137,217	45,526	11,069	1,145	112	0	0	0	0	0	0	0	0	0	0
2001	0	0	141,504	124,214	26,316	5,148	423	0	0	0	0	0	0	0	0	0	0
2002	0	6,452	13,217	110,592	94,169	21,982	244	0	394	0	0	0	0	0	0	0	0
2003	0	14,672	52,512	34,528	102,484	41,375	5,760	0	0	0	0	0	0	0	0	0	0
2004	0	18,746	33,734	134,010	14,587	16,564	3,407	0	0	0	0	0	0	0	0	0	0
2005	0	3,799	102,844	46,076	153,325	2,048	3,247	79	9	14	0	0	0	0	0	0	0
2006	27	8,728	28,442	121,853	22,392	28,622	1,369	530	542	5	0	0	0	0	0	0	0
2007	23	1,451	52,053	110,524	110,351	8,306	6,602	9	11	0	0	0	0	0	0	0	0
2008	110	4,558	64,400	117,489	58,727	37,397	2,826	131	0	0	0	0	0	0	0	0	0
2009	18	4,860	44,423	97,205	67,844	21,111	11,863	184	303	0	0	0	0	0	0	0	0
2010	0	3,552	48,239	127,212	78,138	46,935	9,364	1,382	0	0	0	0	0	0	0	0	0
2011	626	7,071	43,222	104,012	87,852	20,425	4,033	363	128	0	0	0	0	0	0	0	0
2012	0	3,920	31,799	39,339	14,554	5,565	505	249	21	0	0	0	0	0	0	0	0
2013	0	1,576	70,509	37,997	12,157	3,354	326	51	3	0	0	0	0	0	0	0	0

Table A20. Mean weights-at-age (kg) of recreationally discarded Gulf of Maine Atlantic cod (*Gadus morhua*) from 1981 to 2013.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16
1981		0.367	0.456	0.492													
1982		0.307	0.400	0.450	0.509												
1983		0.260	0.386	0.326													
1984		0.288	0.387	0.436													
1985		0.272	0.395	0.426													
1986		0.319	0.380	0.429	0.499												
1987		0.221	0.393	0.371													
1988		0.185	0.357	0.438													
1989		0.395	0.524	0.692	0.867												
1990		0.231	0.528	0.637	0.786												
1991		0.234	0.536	0.776	0.819	0.818											
1992		0.217	0.590	0.724	0.837	0.902	0.868										
1993		0.252	0.487	0.769	0.794												
1994		0.283	0.470	0.740	0.683												
1995		0.302	0.520	0.635	0.870	0.931											
1996		0.277	0.655	0.827	0.902	0.918											
1997		0.196	0.685	0.915	1.095	1.092	1.294										
1998		0.203	0.630	1.007	1.072	1.211	1.365										
1999		0.301	0.535	0.869	1.078	1.157	1.097	1.456									
2000		0.275	0.574	0.911	1.109	1.003	1.211										
2001			0.581	0.886	1.098	1.105	1.290										
2002		0.156	0.468	1.035	1.406	1.444	1.371		1.937								
2003		0.345	0.544	1.223	1.327	1.507	1.422										
2004		0.142	0.523	0.963	1.429	1.528	1.721										
2005		0.213	0.509	1.012	1.050	1.034	1.316	1.940	2.516	1.734							
2006	0.086	0.304	0.565	0.869	1.216	1.346	1.263	1.773	1.656	2.851							
2007	0.048	0.167	0.642	1.062	1.289	1.603	1.548	2.768	3.977								
2008	0.105	0.320	0.817	1.119	1.296	1.285	1.744	5.263									
2009	0.057	0.315	0.803	1.194	1.338	1.381	1.544	2.142	1.739								
2010		0.282	0.952	1.059	1.448	1.528	1.449	3.196									
2011	0.084	0.322	0.873	1.341	1.328	1.497	1.631	1.834	2.221								
2012		0.298	0.571	0.777	0.931	0.979	2.747	3.907	6.487								
2013		0.345	0.623	0.893	1.072	1.216	1.418	1.632	2.045								

Table A21. Total catch-at-age (numbers, 000s of fish) of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013 with an age 9^{+} group. *Only ages 1 through the* 9^{+} *group are used as assessment model inputs.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9^{+}
1982	1.3	448.8	2,926.5	2,287.2	1,430.7	748.8	65.9	94.1	72.6	90.1
1983	13.6	597.5	2,462.0	2,913.2	1,201.6	704.0	452.7	50.0	62.5	56.2
1984	18.3	370.3	2,129.6	1,675.9	1,643.6	437.5	219.6	105.6	9.5	53.4
1985	67.1	505.7	1,944.3	2,405.1	1,151.8	738.1	161.4	107.2	48.4	33.2
1986	17.8	760.7	1,747.0	2,747.8	992.0	279.3	202.7	48.0	38.2	47.5
1987	100.7	281.8	2,018.3	1,568.3	1,574.5	345.4	89.4	81.0	14.5	37.5
1988	3.4	415.1	1,542.8	2,086.6	1,156.9	447.7	67.4	25.6	26.2	9.3
1989	0.0	166.4	1,247.2	2,385.1	1,651.9	521.1	87.1	70.3	9.4	19.6
1990	0.0	65.5	812.5	5,547.8	2,717.6	541.4	189.1	29.7	36.4	43.3
1991	3.3	121.6	499.6	942.7	5,561.3	1,037.9	150.7	55.5	26.0	15.8
1992	23.8	370.3	830.1	867.6	502.1	2,190.0	226.2	80.2	6.0	5.5
1993	26.6	105.9	512.3	2,149.0	944.7	103.3	497.1	41.6	11.3	0.0
1994	11.7	124.0	201.9	1,525.6	1,294.2	266.3	66.2	74.2	28.7	7.9
1995	11.6	78.9	319.5	1,321.8	1,260.4	221.7	29.9	6.5	18.2	2.8
1996	22.1	37.5	111.6	627.7	2,003.9	405.9	36.7	4.0	0.5	1.6
1997	1.5	69.1	137.5	519.6	467.8	869.2	72.5	5.5	2.3	1.0
1998	0.9	5.9	171.1	492.3	628.9	152.8	205.9	28.7	5.2	2.3
1999	0.1	73.9	90.9	347.8	336.6	172.3	53.7	59.5	12.4	1.1
2000	0.0	24.8	485.0	556.5	813.7	176.6	85.2	12.5	10.5	0.0
2001	0.0	0.6	394.0	1,163.8	684.4	385.5	106.6	57.2	8.3	11.6
2002	0.0	16.8	41.6	374.9	912.6	323.8	163.5	66.4	28.1	20.3
2003	22.9	44.9	125.6	167.8	582.1	706.1	186.0	75.7	29.2	26.8
2004	0.2	149.4	105.9	609.3	259.7	407.4	251.6	68.4	33.0	27.4
2005	1.5	23.5	180.1	159.6	945.8	89.2	246.6	109.1	28.5	31.7
2006	0.2	19.2	59.1	426.6	290.1	461.7	30.3	79.7	39.0	27.3
2007	0.4	12.2	108.5	299.4	976.4	137.4	230.2	7.9	19.2	22.0
2008	0.4	12.2	130.5	598.4	707.4	780.5	86.4	110.6	4.0	16.6
2009	0.1	10.7	101.5	622.5	1,093.3	477.9	304.8	20.9	30.5	9.6
2010	0.2	8.2	83.6	394.5	888.5	668.3	164.3	71.7	11.2	7.6
2011	0.7	8.7	60.5	322.2	589.6	573.9	339.9	34.9	38.4	9.4
2012	0.0	10.4	87.0	302.8	438.0	246.1	125.4	59.0	7.6	3.5
2013	0.5	5.0	162.5	282.7	178.1	117.3	21.7	12.2	6.8	0.9

Table A22. Mean weights-at-age (kg) of the total catch Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013 an age 9^+ group. Mean catch weights-at-age in the 9^+ group were estimated using a numbers weighted approach. Cells shaded grey were imputed using a 5-year centered moving average. *Only ages 1 through the 9^+ group are used as assessment model inputs.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9^+
1982	0.012	0.356	0.858	1.514	2.606	5.067	7.065	9.620	9.771	15.664
1983	0.024	0.224	0.768	1.542	2.418	3.808	6.055	6.071	10.317	13.325
1984	0.001	0.234	0.653	1.478	2.678	3.609	5.540	8.368	10.138	14.828
1985	0.039	0.206	0.733	1.404	2.819	4.658	5.884	8.502	11.244	13.676
1986	0.005	0.277	0.501	1.698	2.774	4.778	6.504	8.109	10.206	14.646
1987	0.004	0.154	0.642	1.323	3.090	4.668	7.259	10.036	11.099	14.582
1988	0.003	0.122	0.577	1.666	2.360	5.205	5.200	6.193	10.103	12.993
1989	0.046	0.236	0.752	1.518	2.959	4.282	5.980	9.276	12.519	20.913
1990	0.021	0.193	0.811	1.349	2.141	4.474	7.721	10.820	11.750	18.718
1991	0.014	0.236	1.113	1.601	2.281	3.894	7.144	10.429	12.261	14.031
1992	0.023	0.055	1.033	1.530	2.747	2.976	5.587	10.921	10.483	14.483
1993	0.021	0.081	0.690	1.748	2.150	4.420	5.670	9.817	13.673	15.701
1994	0.022	0.058	0.730	1.712	3.085	3.251	6.335	7.684	12.542	11.846
1995	0.027	0.103	1.288	1.591	2.649	5.090	6.865	11.466	13.128	22.443
1996	0.033	0.100	1.293	2.096	2.260	3.462	7.558	11.728	14.455	16.269
1997	0.017	0.064	1.351	2.128	3.022	3.074	4.699	9.000	12.156	16.938
1998	0.008	0.202	1.071	1.931	2.633	3.972	4.255	7.122	12.118	16.676
1999	0.052	0.222	0.635	1.723	2.777	3.892	5.670	6.704	9.811	12.279
2000	0.030	0.282	1.081	2.150	3.316	4.325	5.898	5.352	9.331	12.680
2001	0.045	0.316	0.890	2.176	3.144	4.666	6.140	7.273	9.072	9.559
2002	0.032	0.185	0.795	1.797	2.906	3.792	6.132	6.969	8.808	12.205
2003	0.038	0.202	0.809	1.843	2.378	3.654	5.112	7.649	9.191	12.058
2004	0.025	0.111	0.483	1.606	2.965	3.547	5.350	7.220	9.764	13.303
2005	0.027	0.126	0.558	1.625	2.401	4.233	4.502	6.349	8.002	12.549
2006	0.071	0.289	0.648	1.493	2.932	3.357	4.463	5.562	7.430	12.146
2007	0.025	0.220	0.744	1.731	2.922	3.735	4.771	6.167	7.302	12.394
2008	0.085	0.247	0.862	2.179	2.818	3.530	3.988	5.819	7.528	12.044
2009	0.032	0.337	0.911	2.153	3.126	3.575	4.368	5.959	8.000	12.887
2010	0.023	0.264	1.200	1.995	3.203	3.914	4.447	5.708	8.730	11.612
2011	0.086	0.329	0.933	2.056	2.874	3.870	4.839	5.717	5.953	12.984
2012	0.011	0.271	0.991	1.968	2.655	3.088	4.088	5.142	5.309	9.895
2013	0.050	0.499	0.932	1.909	2.382	3.181	3.487	5.226	7.018	11.150

Table A23. Mean January 1/spawning stock weights-at-age (kg) of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013 an age 9^+ group. Weights were estimated from catch weights using Rivard-type approach (see NEFSC 2013) approach. Cells shaded grey were imputed using a 5-year centered moving average. *Only ages 1 through the 9^+ group are used as assessment model inputs.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9^+
1982	0.002	0.241	0.594	1.165	2.127	4.635	7.622	9.289	9.695	15.664
1983	0.008	0.050	0.501	1.114	1.894	3.136	5.539	6.549	9.962	13.325
1984	0.000	0.075	0.372	1.019	2.021	2.952	4.593	7.118	7.845	14.828
1985	0.015	0.014	0.403	0.910	2.013	3.532	4.608	6.863	9.700	13.676
1986	0.001	0.104	0.316	1.077	1.917	3.670	5.504	6.908	9.315	14.646
1987	0.001	0.028	0.406	0.777	2.273	3.574	5.889	8.079	9.487	14.582
1988	0.000	0.022	0.293	0.980	1.709	4.010	4.927	6.705	10.069	12.993
1989	0.022	0.027	0.292	0.887	2.179	3.172	5.578	6.945	8.799	20.913
1990	0.006	0.095	0.431	0.937	1.742	3.627	5.750	8.043	10.440	18.718
1991	0.007	0.071	0.450	1.083	1.689	2.846	5.654	8.972	11.518	14.060
1992	0.012	0.028	0.476	1.215	2.026	2.564	4.629	8.832	10.453	14.483
1993	0.012	0.046	0.191	1.254	1.702	3.449	4.083	7.388	12.219	15.708
1994	0.010	0.038	0.236	1.003	2.244	2.571	5.294	6.601	11.095	11.846
1995	0.012	0.051	0.275	0.946	2.021	3.934	4.722	8.526	10.045	22.443
1996	0.022	0.060	0.356	1.462	1.784	2.971	6.185	8.967	12.844	16.357
1997	0.005	0.049	0.391	1.466	2.407	2.571	3.973	8.245	11.940	16.938
1998	0.002	0.059	0.256	1.445	2.245	3.423	3.558	5.739	10.442	16.676
1999	0.022	0.044	0.343	1.196	2.237	3.139	4.752	5.301	8.351	12.279
2000	0.009	0.120	0.461	1.063	2.257	3.422	4.773	5.508	7.882	12.661
2001	0.023	0.097	0.456	1.305	2.420	3.851	5.091	6.513	6.912	9.538
2002	0.012	0.089	0.465	1.050	2.249	3.247	5.296	6.514	7.924	12.152
2003	0.022	0.089	0.346	1.053	1.742	2.977	4.118	6.837	8.011	12.023
2004	0.011	0.066	0.351	0.971	2.110	2.620	4.199	5.908	8.627	13.288
2005	0.008	0.060	0.248	0.821	1.654	3.338	3.841	5.758	7.593	12.546
2006	0.043	0.089	0.295	0.808	1.890	2.467	4.076	4.912	6.744	12.137
2007	0.009	0.124	0.450	0.925	1.771	3.005	3.723	5.020	6.329	12.394
2008	0.046	0.085	0.420	1.117	1.888	2.892	3.630	5.147	6.803	12.040
2009	0.014	0.171	0.480	1.248	2.283	2.908	3.658	4.735	6.735	12.878
2010	0.006	0.100	0.589	1.168	2.328	3.198	3.685	4.778	7.153	11.612
2011	0.084	0.087	0.492	1.353	1.972	3.262	4.114	4.788	5.751	12.995
2012	0.002	0.157	0.512	1.221	2.083	2.693	3.866	4.930	5.464	9.895
2013	0.035	0.070	0.474	1.154	1.906	2.757	3.168	4.591	5.993	11.150

Table A24. Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl survey indices for Gulf of Maine Atlantic cod (*Gadus morhua*) from 1963 to 2014. *Note: the spring survey did not begin until 1968, 2014 spring data have not been aged and the 2014 fall survey has not been conducted at the time of this report.*

Year	Abundance (numbers/tow)		Biomass (kg/tow)	
	Spring	Fall	Spring	Fall
1963		5.914		17.950
1964		4.015		22.799
1965		4.500		12.089
1966		3.720		12.838
1967		2.602		9.313
1968	5.329	4.374	17.480	19.437
1969	3.215	2.758	13.100	15.154
1970	2.191	4.905	11.089	16.442
1971	1.429	4.361	7.004	16.529
1972	2.057	9.301	8.031	12.988
1973	7.525	4.452	18.807	8.764
1974	2.902	4.328	7.419	8.959
1975	2.512	6.143	6.039	8.619
1976	2.782	2.148	7.556	6.740
1977	3.872	3.073	8.541	10.199
1978	2.050	5.773	7.697	12.899
1979	3.644	3.142	7.555	13.927
1980	2.155	7.035	6.232	14.202
1981	4.832	2.349	10.650	7.533
1982	3.763	7.769	8.616	15.919
1983	3.912	2.786	10.962	8.416
1984	3.667	2.449	6.143	8.735
1985	2.517	2.821	7.645	8.264
1986	1.957	1.950	3.476	4.715
1987	1.083	2.996	1.976	3.394
1988	3.127	5.903	3.603	6.616
1989	2.112	4.553	2.424	4.535
1990	2.362	2.986	3.077	4.912
1991	2.393	1.252	2.891	2.782
1992	2.435	1.434	8.627	2.448
1993	2.507	1.232	5.875	1.003
1994	1.271	2.130	2.428	2.737
1995	1.930	2.008	2.432	3.665
1996	2.465	1.327	5.427	2.352
1997	2.192	0.872	5.616	1.872
1998	1.710	0.843	4.180	1.501
1999	2.301	1.807	5.090	3.505
2000	3.083	2.604	3.211	4.652
2001	2.147	1.980	6.215	7.324
2002	3.724	5.328	10.934	24.659
2003	3.677	2.529	9.495	5.988
2004	0.981	3.533	2.412	4.906
2005	1.765	1.338	2.701	2.897
2006	1.363	3.594	2.702	4.229
2007	12.393	1.992	15.811	2.714
2008	7.990	3.460	10.823	5.307
2009	3.599	3.447	7.161	5.845
2010	1.296	0.948	3.336	2.572
2011	0.894	0.990	2.133	2.647
2012	0.893	0.452	1.645	1.024
2013	0.909	0.587	1.678	1.068
2014	0.598		1.338	
Avg	2.883	3.231	6.580	8.051
Min	0.598	0.452	1.338	1.003
Max	12.393	9.301	18.807	24.659

Table A25. Coefficients of variation (CV) for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl survey indices for Gulf of Maine Atlantic cod (*Gadus morhua*) from 1963 to 2014. *Note: the spring survey did not begin until 1968, 2014 spring data have not been aged and the 2014 fall survey has not been conducted at the time of this report.*

Year	Abundance (numbers/tow)		Biomass (kg/tow)	
	Spring	Fall	Spring	Fall
1963		0.25		0.39
1964		0.41		0.50
1965		0.27		0.27
1966		0.22		0.23
1967		0.22		0.22
1968	0.13	0.18	0.15	0.20
1969	0.33	0.15	0.33	0.22
1970	0.21	0.32	0.24	0.25
1971	0.19	0.20	0.21	0.31
1972	0.21	0.53	0.23	0.20
1973	0.33	0.15	0.41	0.27
1974	0.19	0.26	0.20	0.20
1975	0.22	0.23	0.25	0.15
1976	0.18	0.20	0.17	0.21
1977	0.27	0.12	0.21	0.13
1978	0.19	0.19	0.21	0.15
1979	0.23	0.11	0.18	0.13
1980	0.17	0.26	0.18	0.15
1981	0.19	0.22	0.20	0.23
1982	0.22	0.64	0.22	0.67
1983	0.26	0.17	0.22	0.19
1984	0.44	0.22	0.32	0.33
1985	0.20	0.18	0.22	0.35
1986	0.31	0.23	0.20	0.23
1987	0.26	0.31	0.31	0.23
1988	0.21	0.35	0.28	0.23
1989	0.18	0.22	0.21	0.18
1990	0.25	0.19	0.28	0.20
1991	0.25	0.27	0.24	0.25
1992	0.32	0.21	0.37	0.24
1993	0.22	0.26	0.35	0.26
1994	0.22	0.31	0.22	0.29
1995	0.27	0.30	0.26	0.32
1996	0.24	0.25	0.28	0.25
1997	0.17	0.30	0.19	0.31
1998	0.34	0.35	0.32	0.29
1999	0.24	0.18	0.32	0.19
2000	0.22	0.31	0.15	0.33
2001	0.31	0.27	0.33	0.28
2002	0.20	0.58	0.22	0.69
2003	0.22	0.31	0.37	0.25
2004	0.26	0.33	0.29	0.21
2005	0.24	0.06	0.25	0.23
2006	0.20	0.30	0.25	0.19
2007	0.66	0.37	0.54	0.28
2008	0.72	0.39	0.61	0.28
2009	0.53	0.54	0.49	0.43
2010	0.24	0.23	0.26	0.30
2011	0.28	0.30	0.20	0.34
2012	0.19	0.22	0.21	0.23
2013	0.28	0.25	0.28	0.24
2014	0.23		0.24	
Avg	0.27	0.27	0.27	0.27
Min	0.13	0.06	0.15	0.13
Max	0.72	0.64	0.61	0.69

Table A26. Northeast Fisheries Science Center (NEFSC) spring survey abundance indices-at-age (numbers/tow) from 1970 to 2013 for Gulf of Maine Atlantic cod (*Gadus morhua*). *Note: age data are not available prior to 1970 and 2014 spring survey data have not been aged at the time of this report.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17
1970	0.000	0.159	0.124	0.053	0.098	0.290	0.475	0.589	0.073	0.045	0.076	0.133	0.059	0.000	0.018	0.000	0.000	0.000
1971	0.000	0.069	0.109	0.099	0.280	0.086	0.096	0.280	0.207	0.142	0.050	0.013	0.000	0.000	0.000	0.000	0.000	0.000
1972	0.053	0.300	0.153	0.499	0.208	0.205	0.052	0.083	0.119	0.300	0.027	0.017	0.026	0.000	0.017	0.000	0.000	0.000
1973	0.000	0.053	4.273	0.917	0.614	0.384	0.144	0.106	0.186	0.276	0.186	0.072	0.113	0.112	0.088	0.000	0.000	0.000
1974	0.164	0.311	0.081	1.534	0.177	0.231	0.082	0.000	0.064	0.038	0.089	0.043	0.037	0.000	0.016	0.000	0.035	0.000
1975	0.012	0.094	0.707	0.095	1.139	0.246	0.073	0.000	0.006	0.025	0.028	0.026	0.062	0.000	0.000	0.000	0.000	0.000
1976	0.000	0.052	0.253	1.114	0.150	0.870	0.131	0.056	0.038	0.000	0.036	0.000	0.054	0.027	0.000	0.000	0.000	0.000
1977	0.000	0.068	0.264	0.460	2.015	0.139	0.775	0.000	0.114	0.000	0.000	0.000	0.000	0.000	0.031	0.000	0.000	0.006
1978	0.000	0.070	0.083	0.297	0.383	0.764	0.084	0.226	0.013	0.108	0.000	0.022	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.044	0.426	1.407	0.186	0.470	0.301	0.549	0.094	0.104	0.013	0.031	0.020	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.070	0.037	0.500	0.436	0.123	0.294	0.226	0.337	0.000	0.105	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.000	1.091	0.619	0.850	1.335	0.318	0.304	0.080	0.144	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.014	0.357	1.040	0.498	0.737	0.848	0.083	0.135	0.000	0.040	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.013	0.610	0.968	1.042	0.453	0.336	0.250	0.060	0.000	0.071	0.033	0.017	0.045	0.000	0.016	0.000	0.000	0.000
1984	0.000	0.151	1.309	0.987	0.853	0.229	0.047	0.090	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.000	0.029	0.238	0.676	0.612	0.707	0.094	0.109	0.026	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.537	0.259	0.767	0.218	0.075	0.046	0.038	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.000	0.000
1987	0.000	0.030	0.471	0.191	0.222	0.075	0.000	0.068	0.011	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.000	0.000
1988	0.029	0.719	0.926	0.791	0.283	0.205	0.099	0.036	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.025	0.609	0.712	0.630	0.069	0.068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.000	0.009	0.233	1.325	0.669	0.076	0.032	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.000	0.028	0.077	0.233	1.750	0.247	0.041	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.000	0.050	0.247	0.223	0.248	1.368	0.213	0.073	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.201	0.507	0.804	0.364	0.084	0.446	0.055	0.023	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.000	0.015	0.316	0.407	0.201	0.083	0.053	0.142	0.009	0.027	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.037	0.187	1.165	0.321	0.147	0.034	0.000	0.011	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.000	0.057	0.022	0.586	1.355	0.385	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.159	0.139	0.390	0.271	0.874	0.244	0.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.000	0.018	0.228	0.359	0.513	0.143	0.408	0.021	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.000	0.166	0.342	0.726	0.351	0.305	0.134	0.266	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000
2000	0.026	1.173	0.737	0.438	0.485	0.099	0.092	0.011	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.000	0.029	0.355	0.683	0.510	0.342	0.065	0.097	0.055	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.340	0.045	0.548	1.584	0.606	0.342	0.185	0.057	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.000	0.075	0.825	0.059	0.718	1.072	0.387	0.340	0.081	0.082	0.030	0.011	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.136	0.045	0.230	0.116	0.208	0.213	0.011	0.011	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.029	0.739	0.081	0.623	0.011	0.138	0.128	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.028	0.184	0.237	0.434	0.049	0.197	0.023	0.126	0.069	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.100	3.422	3.077	4.446	0.437	0.796	0.075	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.079	1.165	3.930	1.582	1.099	0.053	0.082	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.063	0.279	1.050	1.135	0.600	0.438	0.008	0.022	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.059	0.279	0.335	0.197	0.229	0.113	0.043	0.016	0.010	0.005	0.000	0.010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.005	0.024	0.140	0.383	0.189	0.086	0.033	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.069	0.105	0.224	0.243	0.159	0.051	0.036	0.004	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.012	0.283	0.224	0.162	0.165	0.044	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A27. Northeast Fisheries Science Center (NEFSC) fall survey abundance indices-at-age (numbers/tow) from 1970 to 2013 for Gulf of Maine Atlantic cod (*Gadus morhua*). *Note: age data are not available prior to 1970.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16	Age17
1970	0.743	0.938	0.254	0.520	0.336	0.487	0.424	0.836	0.130	0.090	0.037	0.037	0.073	0.000	0.000	0.000	0.000	0.000
1971	1.334	0.207	0.224	0.190	0.607	0.444	0.509	0.222	0.280	0.193	0.031	0.040	0.081	0.000	0.000	0.000	0.000	0.000
1972	0.031	5.663	1.118	1.595	0.181	0.072	0.122	0.031	0.121	0.351	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.000
1973	0.638	0.327	2.146	0.179	0.540	0.191	0.055	0.018	0.039	0.182	0.122	0.000	0.000	0.016	0.000	0.000	0.000	0.000
1974	0.265	1.131	0.267	1.922	0.125	0.276	0.000	0.052	0.036	0.066	0.000	0.120	0.000	0.000	0.069	0.000	0.000	0.000
1975	0.006	0.223	3.028	0.139	2.354	0.250	0.105	0.020	0.000	0.000	0.000	0.006	0.012	0.000	0.000	0.000	0.000	0.000
1976	0.000	0.209	0.216	0.578	0.104	0.835	0.044	0.099	0.000	0.000	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.000	0.046	0.446	0.456	1.151	0.133	0.604	0.024	0.083	0.021	0.061	0.000	0.022	0.026	0.000	0.000	0.000	0.000
1978	0.241	1.411	0.359	1.141	0.661	1.450	0.101	0.269	0.012	0.082	0.000	0.019	0.000	0.028	0.000	0.000	0.000	0.000
1979	0.000	0.364	0.617	0.131	0.696	0.319	0.754	0.056	0.135	0.000	0.053	0.000	0.000	0.000	0.005	0.013	0.000	0.000
1980	0.027	1.319	2.558	1.664	0.518	0.236	0.402	0.192	0.022	0.012	0.000	0.049	0.000	0.014	0.000	0.000	0.022	0.000
1981	0.010	0.581	0.399	0.469	0.509	0.092	0.081	0.081	0.099	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.000	0.835	3.264	2.476	0.971	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.000	0.305	0.905	0.757	0.267	0.250	0.219	0.000	0.000	0.000	0.018	0.028	0.037	0.000	0.000	0.000	0.000	0.000
1984	0.000	0.513	0.418	0.586	0.384	0.196	0.194	0.062	0.000	0.016	0.000	0.000	0.045	0.035	0.000	0.000	0.000	0.000
1985	0.218	0.445	0.917	0.627	0.201	0.246	0.064	0.000	0.034	0.070	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.394	0.404	0.626	0.368	0.073	0.041	0.000	0.000	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.128	0.570	1.388	0.586	0.198	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.000	1.889	2.366	1.069	0.367	0.146	0.000	0.044	0.000	0.011	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.145	2.468	1.458	0.283	0.138	0.053	0.000	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.000	0.057	0.218	1.788	0.611	0.255	0.048	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.009	0.144	0.151	0.230	0.621	0.075	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.059	0.289	0.448	0.144	0.041	0.327	0.126	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.031	0.210	0.575	0.361	0.017	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.032	0.184	0.909	0.816	0.093	0.051	0.000	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.008	0.068	0.308	1.226	0.304	0.082	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.029	0.122	0.379	0.231	0.516	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.297	0.091	0.165	0.168	0.151	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.050	0.085	0.342	0.110	0.185	0.041	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.025	0.432	0.375	0.590	0.244	0.122	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.008	0.540	0.981	0.399	0.492	0.140	0.010	0.000	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.018	0.000	0.171	0.720	0.478	0.356	0.124	0.092	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.000	0.269	0.104	0.333	2.683	1.070	0.750	0.077	0.043	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.542	0.461	0.186	0.216	0.518	0.451	0.071	0.062	0.000	0.011	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000
2004	1.369	0.661	0.172	0.577	0.254	0.250	0.149	0.057	0.023	0.010	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.034	0.153	0.378	0.078	0.456	0.023	0.090	0.082	0.023	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.064	1.241	0.599	1.007	0.252	0.293	0.037	0.053	0.036	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.011	0.136	0.863	0.395	0.496	0.023	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.165	0.650	1.227	1.060	0.189	0.139	0.000	0.000	0.000	0.010	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.020	0.660	2.096	0.314	0.277	0.045	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.008	0.094	0.132	0.290	0.288	0.092	0.023	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000
2011	0.036	0.060	0.091	0.210	0.304	0.175	0.078	0.005	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.079	0.087	0.135	0.092	0.032	0.011	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	0.010	0.020	0.243	0.221	0.064	0.014	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A28. Massachusetts Division of Marine Fisheries (MADMF) spring survey indices and the corresponding CVs from 1978 to 2014 for Gulf of Maine Atlantic cod (*Gadus morhua*). *Note that 2014 spring survey data have not been aged at the time of this report.*

Year	Abundance (numbers/tow)		Biomass (kg/tow)	
	Index	CV	Index	CV
1978	47.887	0.15	11.058	0.14
1979	96.559	0.28	14.276	0.22
1980	65.979	0.12	14.509	0.13
1981	69.406	0.21	18.689	0.27
1982	25.842	0.22	12.161	0.17
1983	54.850	0.17	18.746	0.15
1984	10.330	0.29	7.240	0.26
1985	8.455	0.21	4.765	0.19
1986	24.089	0.55	7.841	0.35
1987	17.206	0.22	7.865	0.27
1988	22.242	0.21	7.703	0.24
1989	52.244	0.27	17.346	0.34
1990	32.409	0.29	15.879	0.34
1991	13.699	0.22	8.730	0.12
1992	16.924	0.29	8.766	0.32
1993	92.659	0.34	5.861	0.27
1994	16.358	0.23	4.334	0.24
1995	23.364	0.26	3.993	0.23
1996	12.961	0.22	3.152	0.31
1997	17.887	0.24	2.500	0.25
1998	27.570	0.26	3.250	0.47
1999	161.058	0.37	8.997	0.26
2000	50.771	0.39	20.604	0.46
2001	41.844	0.43	26.445	0.54
2002	24.338	0.10	11.158	0.39
2003	1120.371	0.51	10.984	0.22
2004	131.589	0.46	8.147	0.28
2005	193.262	0.22	10.402	0.20
2006	1077.030	0.34	9.177	0.18
2007	61.576	0.27	8.430	0.25
2008	482.100	0.20	12.229	0.21
2009	480.516	0.35	4.489	0.19
2010	8.075	0.23	5.645	0.46
2011	59.064	0.53	4.519	0.42
2012	11.465	0.27	2.276	0.40
2013	2.314	0.27	0.953	0.31
2014	19.857	0.16	1.302	0.47
Avg	126.328	0.28	9.309	0.28
Min	2.314	0.10	0.953	0.12
Max	1120.371	0.55	26.445	0.54

Table A29. Massachusetts Division of Marine Fisheries (MADMF) spring survey abundance indices-at-age (numbers/tow) from 1982 to 2013 for Gulf of Maine Atlantic cod (*Gadus morhua*). *Note that age data are not available prior to 1982 and 2014 spring survey age data have not been aged at the time of this report.*

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14
1982	1.668	13.218	6.649	2.921	1.024	0.216	0.049	0.046	0.050	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.718	30.253	17.570	4.710	0.347	1.121	0.075	0.023	0.033	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.257	1.898	5.090	2.101	0.751	0.147	0.086	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	1.569	1.670	2.695	2.024	0.498	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	1.075	18.031	3.376	0.903	0.582	0.100	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.725	8.622	5.376	2.045	0.168	0.147	0.053	0.000	0.000	0.070	0.000	0.000	0.000	0.000	0.000
1988	1.895	10.409	6.750	1.927	1.211	0.016	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.298	21.463	22.947	6.868	0.513	0.108	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	4.930	4.972	5.938	14.182	2.149	0.155	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.355	5.331	2.295	1.801	3.669	0.249	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	1.506	4.379	5.699	3.444	0.484	1.301	0.066	0.044	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	80.090	2.842	6.100	2.509	0.879	0.166	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	4.627	5.406	3.883	1.703	0.608	0.131	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	11.998	5.985	2.420	2.408	0.525	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	8.843	0.777	0.497	0.955	1.590	0.299	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	12.431	2.910	1.035	0.920	0.190	0.383	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	23.481	1.487	0.924	0.779	0.637	0.034	0.211	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	143.000	11.832	2.407	2.275	0.735	0.630	0.036	0.127	0.017	0.000	0.000	0.000	0.000	0.000	0.000
2000	2.151	35.360	6.995	2.371	2.316	0.784	0.663	0.059	0.073	0.000	0.000	0.000	0.000	0.000	0.000
2001	25.987	0.084	4.998	4.710	3.448	1.961	0.323	0.227	0.106	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.924	19.340	0.220	1.379	1.145	0.561	0.318	0.111	0.253	0.025	0.049	0.000	0.012	0.000	0.000
2003	1094.105	17.109	5.496	0.439	1.938	0.937	0.221	0.074	0.014	0.025	0.000	0.014	0.000	0.000	0.000
2004	116.135	8.927	1.882	2.627	0.361	1.083	0.455	0.076	0.029	0.000	0.014	0.000	0.000	0.000	0.000
2005	179.479	5.524	4.141	0.795	1.955	0.263	0.663	0.243	0.094	0.105	0.000	0.000	0.000	0.000	0.000
2006	1053.701	9.992	7.139	3.930	0.525	1.532	0.109	0.057	0.000	0.017	0.028	0.000	0.000	0.000	0.000
2007	49.323	3.776	3.078	2.303	2.163	0.343	0.519	0.025	0.046	0.000	0.000	0.000	0.000	0.000	0.000
2008	456.954	7.275	10.336	3.242	2.287	1.695	0.155	0.155	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	466.098	8.907	2.350	1.654	1.045	0.348	0.112	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	1.165	2.415	1.393	1.423	0.819	0.678	0.129	0.000	0.000	0.000	0.052	0.000	0.000	0.000	0.000
2011	55.378	0.326	1.001	0.621	0.933	0.558	0.139	0.086	0.021	0.000	0.000	0.000	0.000	0.000	0.000
2012	6.239	3.368	0.671	0.446	0.304	0.415	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	1.254	0.284	0.237	0.145	0.232	0.162	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A30. Summary of Gulf of Maine Atlantic cod (*Gadus morhua*) ASAP model diagnostics and terminal estimates from the M=0.2 and M-ramp models. See NEFSC (2013) for a full description of model configurations - no changes have been made to the model configurations as part of the 2014 Update.

Model		M=0.2	M-ramp
Description		M=0.2	M=0.2 (1982-1988), linear ramp (1989-2002), M=0.4 (2003-2013)
Maximum gradient (*conv. criteria < 1e-4*)		1.12E-04	4.30E-05
Number of parameters		97	97
Objective function		2190	2182
Components of objective function	Recruit devs	64	65
	Suvey age comps	649	647
	Catch age comps	418	419
	Index fit	837	830
	Catch fit	222	221
RMSE	Catch	0.24	0.17
	NEFSC spring	1.09	0.97
	NEFSC fall	0.93	0.95
	MADMF spring	1.18	1.07
	Index total	1.07	1.00
	Recruit devs	1.71	1.42
SSB_{1982} (mt)		22,536	22,041
SSB_{2013} (mt)		2,063	2,432
$F_{mult, 2013}$		1.33	1.24
Median $recruitment_{1982-2011}$ (000s)		4,648	9,144
Median $recruitment_{2002-2011}$ (000s)		3,487	7,409
Mohn's rho (7 year peel)	SSB	0.53	0.17
	F_{mult}	-0.33	-0.05
	Age 1 N	1.05	0.42
Survey catchability (q)	NEFSC spring	1.06 *(0.17)*	0.93 *(0.17)*
	NEFSC fall	0.67 *(0.23)*	0.58 *(0.23)*
	MADMF spring	0.23 *(0.12)*	0.12 *(0.12)*

Table A31. Comparison of the fleet and index selectivity parameters and the corresponding coefficients of variation (CV) from the Gulf of Maine Atlantic cod (*Gadus morhua*) M=0.2 and M-ramp models.

Block/survey	Parameter	M=0.2		M-ramp	
		Value	*CV*	Value	*CV*
Block 1 (1982-1988)	A_{50}	2.33	*0.05*	2.33	*0.05*
	slope up	0.46	*0.09*	0.45	*0.09*
Block 2 (1989 - 2004)	A_{50}	3.32	*0.02*	3.35	*0.02*
	slope up	0.56	*0.05*	0.53	*0.05*
Block 3 (2005-2013)	A_{50}	3.66	*0.03*	3.71	*0.03*
	slope up	0.54	*0.07*	0.51	*0.06*
NEFSC spring	Age1	0.04	*0.24*	0.03	*0.24*
	Age2	0.13	*0.19*	0.11	*0.19*
	Age3	0.27	*0.18*	0.25	*0.18*
	Age4	0.49	*0.18*	0.47	*0.18*
	Age5	0.70	*0.19*	0.70	*0.19*
	Age6	1.00			
	Age7	1.00			
	Age8	1.00			
	$Age9^{+}$	1.00			
NEFSC fall	Age1	0.14	*0.25*	0.11	*0.25*
	Age2	0.32	*0.24*	0.29	*0.24*
	Age3	0.50	*0.24*	0.49	*0.24*
	Age4	0.73	*0.25*	0.73	*0.25*
	Age5	0.86	*0.27*	0.87	*0.27*
	Age6	1.00			
	Age7	1.00			
	Age8	1.00			
	$Age9^{+}$	1.00			
MADMF spring	Age1	1.00			
	Age2	0.69	*0.15*	0.77	*0.15*
	Age3	0.63	*0.18*	0.77	*0.18*
	Age4	0.67	*0.22*	0.86	*0.22*
	Age5	0.73	*0.31*	0.97	*0.31*
	Age6	0.56	*0.58*	0.74	*0.58*

Table A32. Gulf of Maine Atlantic cod (*Gadus morhua*) January 1 biomass and spawning stock biomass from 1982 to 2013 as estimated from the M=0.2 and M-ramp models.

Year	M=0.2		M-ramp	
	January 1 biomass (mt)	Spawning stock biomass (mt)	January 1 biomass (mt)	Spawning stock biomass (mt)
1982	38,242	22,536	37,862	22,041
1983	28,481	16,784	28,256	16,446
1984	22,974	13,791	22,857	13,542
1985	21,406	12,670	21,360	12,489
1986	20,418	11,808	20,433	11,683
1987	19,769	11,431	19,850	11,371
1988	20,115	11,938	20,428	12,033
1989	27,466	15,977	28,508	16,388
1990	33,984	20,818	35,835	21,719
1991	28,108	17,769	29,750	18,622
1992	18,914	11,074	20,370	11,730
1993	14,042	7,816	15,572	8,499
1994	12,997	7,259	14,960	8,237
1995	13,218	8,301	15,858	9,824
1996	13,446	8,636	16,658	10,560
1997	11,303	7,291	14,859	9,423
1998	9,901	6,426	13,873	8,826
1999	10,518	7,003	15,782	10,045
2000	14,937	9,295	22,740	13,297
2001	18,692	12,288	28,034	17,848
2002	17,030	12,304	25,499	17,768
2003	14,305	10,199	20,818	14,292
2004	12,630	8,789	18,387	12,219
2005	11,012	7,408	15,798	10,143
2006	10,724	6,960	15,859	9,615
2007	13,856	8,806	20,106	11,800
2008	15,662	10,096	21,489	13,099
2009	16,237	10,514	21,618	13,348
2010	13,460	8,864	17,165	10,849
2011	9,616	5,834	11,738	6,914
2012	5,634	2,988	7,090	3,560
2013	3,805	2,063	4,787	2,432

Table A33. Gulf of Maine Atlantic cod (*Gadus morhua*) fully recruited fishing mortality (F_{full}) from 1982 to 2013 as estimated from the M=0.2 and M-ramp models.

Year	F_{full}	
	M=0.2	M-ramp
1982	0.73	0.75
1983	0.88	0.90
1984	0.78	0.80
1985	0.92	0.94
1986	0.84	0.85
1987	0.83	0.84
1988	0.63	0.62
1989	0.92	0.93
1990	1.13	1.13
1991	1.26	1.23
1992	1.35	1.31
1993	1.54	1.47
1994	1.46	1.33
1995	1.00	0.87
1996	1.03	0.86
1997	0.93	0.73
1998	0.83	0.61
1999	0.49	0.35
2000	0.62	0.45
2001	0.72	0.51
2002	0.57	0.40
2003	0.67	0.48
2004	0.68	0.50
2005	0.87	0.66
2006	0.73	0.56
2007	0.72	0.57
2008	0.93	0.75
2009	1.03	0.85
2010	1.09	0.92
2011	1.59	1.38
2012	1.85	1.63
2013	1.33	1.24

Table A34. Gulf of Maine Atlantic cod (*Gadus morhua*) January 1 numbers-at-age (000s) from 1982 to 2013 as estimated from the M = 0.2 model. Recruitment summary statistics reported (i.e., median and geometric mean) are provided for various time periods relevant to reference point determination and stock projections.

Model	Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
M=0.2	1982	10,551	12,084	5,097	2,973	1,698	158	223	148	235
	1983	11,537	8,316	7,782	2,298	1,189	668	62	88	150
	1984	11,464	9,027	5,114	3,128	801	407	228	21	81
	1985	8,910	9,013	5,720	2,215	1,192	300	152	85	38
	1986	14,101	6,957	5,467	2,223	741	391	98	50	40
	1987	15,004	11,055	4,332	2,267	804	263	139	35	32
	1988	27,940	11,769	6,907	1,812	829	289	94	50	24
	1989	4,278	22,147	7,855	3,403	806	364	126	41	32
	1990	4,221	3,453	16,742	4,610	1,368	274	119	41	24
	1991	7,490	3,395	2,563	9,105	1,575	381	73	32	17
	1992	7,439	6,012	2,492	1,329	2,811	387	89	17	11
	1993	9,652	5,963	4,378	1,251	383	633	83	19	6
	1994	3,251	7,715	4,274	2,058	313	72	113	15	4
	1995	3,449	2,602	5,569	2,069	548	64	14	22	4
	1996	2,738	2,780	1,954	3,181	785	174	20	4	8
	1997	4,502	2,206	2,081	1,101	1,173	240	51	6	3
	1998	3,937	3,633	1,667	1,219	441	397	78	17	3
	1999	7,871	3,182	2,768	1,011	526	164	143	28	7
	2000	4,697	6,396	2,497	1,900	568	271	83	72	18
	2001	1,171	3,809	4,961	1,633	962	257	119	36	39
	2002	5,199	948	2,930	3,132	767	397	103	48	30
	2003	1,897	4,219	739	1,952	1,652	365	185	48	36
	2004	6,175	1,537	3,258	474	951	712	153	77	35
	2005	3,767	5,002	1,186	2,088	230	408	298	64	47
	2006	6,226	3,065	3,941	797	969	84	141	102	38
	2007	4,600	5,071	2,429	2,732	405	403	33	56	55
	2008	3,208	3,746	4,023	1,690	1,401	171	162	13	44
	2009	2,100	2,609	2,945	2,671	758	489	56	53	19
	2010	1,310	1,706	2,041	1,908	1,116	239	144	16	21
	2011	1,535	1,064	1,332	1,307	771	336	67	40	10
	2012	2,557	1,243	812	761	381	146	57	11	8
	2013	708	2,066	938	438	187	57	19	7	3
	1982-2011 median	4,648								
	2002 - 2011 geomean	3,125								
	2009-2013 geomean	1,502								

Table A35. Gulf of Maine Atlantic cod (*Gadus morhua*) January 1 numbers-at-age (000s) from 1982 to 2013 as estimated from the M-ramp model. Recruitment summary statistics reported (i.e., median and geometric mean) are provided for various time periods relevant to reference point determination and stock projections.

Model	Year	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
M-ramp	1982	10,881	12,245	5,128	2,956	1,663	154	214	142	221
	1983	11,907	8,577	7,856	2,279	1,163	644	59	83	140
	1984	11,767	9,318	5,250	3,104	779	390	215	20	74
	1985	9,226	9,252	5,879	2,238	1,162	287	143	79	35
	1986	14,427	7,205	5,585	2,243	734	373	92	46	36
	1987	15,702	11,315	4,472	2,286	800	257	130	32	29
	1988	30,101	12,324	7,058	1,853	827	284	91	46	22
	1989	4,769	23,884	8,245	3,485	827	364	125	40	30
	1990	4,926	3,823	18,075	4,855	1,372	274	117	40	22
	1991	9,061	3,862	2,795	9,751	1,609	369	71	30	16
	1992	9,545	7,023	2,774	1,442	2,959	389	85	16	11
	1993	13,331	7,317	4,966	1,378	406	655	82	18	6
	1994	4,835	9,999	5,013	2,292	337	76	116	14	4
	1995	5,589	3,596	6,855	2,407	622	72	15	23	4
	1996	4,850	4,139	2,525	3,813	922	203	23	5	9
	1997	8,547	3,521	2,850	1,381	1,440	297	63	7	4
	1998	7,849	6,152	2,424	1,613	571	521	105	22	4
	1999	16,624	5,602	4,229	1,414	723	229	204	41	10
	2000	10,204	11,666	3,847	2,642	759	364	114	101	25
	2001	2,570	7,081	7,874	2,301	1,302	344	163	51	56
	2002	11,577	1,765	4,711	4,570	1,073	553	144	68	44
	2003	4,291	7,801	1,160	2,783	2,273	496	252	65	51
	2004	13,976	2,860	5,047	660	1,286	962	206	104	48
	2005	8,347	9,313	1,848	2,854	301	536	394	84	62
	2006	13,594	5,577	6,103	1,086	1,259	110	188	137	51
	2007	9,683	9,086	3,666	3,654	508	502	42	72	72
	2008	6,471	6,472	5,972	2,192	1,704	201	192	16	55
	2009	4,070	4,321	4,227	3,441	908	568	64	61	22
	2010	2,464	2,716	2,812	2,387	1,336	276	164	18	24
	2011	2,813	1,644	1,764	1,566	887	381	74	44	11
	2012	4,422	1,873	1,051	896	434	165	65	13	9
	2013	1,131	2,940	1,187	508	213	65	22	9	3
	1982-2011 median	9,144								
	2002 - 2011 geomean	6,522								
	2009-2013 geomean	2,691								

Table A36. Inputs to the Gulf of Maine Atlantic cod (*Gadus morhua*) yield per recruit (YPR) and projection analyses for the M=0.2 and M-ramp model scenarios.

Age	Natural mortality	Fraction mature	Catch weights (kg)	Stock weights (kg)	Fishery selectivity (M = 0.2)	Fishery selectivity (M-ramp)
1	0.20	0.08	0.37	0.10	0.01	0.01
2	0.20	0.29	0.95	0.49	0.04	0.03
3	0.20	0.66	1.98	1.24	0.23	0.20
4	0.20	0.90	2.64	1.99	0.65	0.64
5	0.20	0.98	3.38	2.90	0.92	0.93
6	0.20	0.99	4.14	3.72	0.99	0.99
7	0.20	1.00	5.36	4.77	1.00	1.00
8	0.20	1.00	6.09	5.74	1.00	1.00
9^{+}	0.20	1.00	11.34	11.35	1.00	1.00

Table A37. Alternate short-term projections (2015-2017) of total fishery yield and spawning stock biomass for Gulf of Maine Atlantic cod (*Gadus morhua*) based on four different harvest scenarios ($F_{MSY\text{-}proxy}$, 75% $F_{MSY\text{-}proxy}$, $F_{rebuild}$, $F_{no\ action}$). These projections have assumed the geometric mean recruitment of the 2009-2013 period for estimating 2014 age-1 recruitment. For age-1 recruitment in 2015 and beyond the projections assume 1982-2011 median recruitment (M=0.2~ 4.6 million fish, M-ramp~ 9.1 million fish) when spawning stock biomass is above 6,300 mt in the M=0.2 model and 7,900 mt in the M-ramp model. At spawning stock levels below these thresholds, recruitment declines linearly to zero. Catch in 2014 has been set at the fishing year 2014 ABC of 1,550 mt. There are two sets of projections for both the M=0.2 and M-ramp models. For the M=0.2 model, the first projection assumes 2014 conditions as determined from the M=0.2 model with no adjustment for retrospective error, the second applies a retrospective adjustment based on ρ=0.53 ((1/1+ ρ)=0.65). The two M-ramp projections differ in the assumed natural mortality rate in subsequent years. One is set at M=0.2 while the other is set at M=0.4 to bracket the range of natural mortality rates used in the M-ramp model. *Note that under the M=0.2 retro adjustment and M-ramp, M=0.4 scenario, the stock cannot rebuild by the 2024 rebuilding date at F=0.*

Harvest strategy	Year	Input	M=0.2 model						M-ramp model					
			No retro adjustment			Retrospective adjustment			M=0.2			M=0.4		
			Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}
F_{MSY}	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91
	2015	Projection	506	3,297	0.18	252	1,703	0.18	584	3,972	0.18	421	3,008	0.18
	2016	Projection	709	4,564	0.18	380	2,504	0.18	868	5,929	0.18	519	3,744	0.18
	2017	Projection	941	6,191	0.18	530	3,501	0.18	1,239	8,497	0.18	622	4,550	0.18
75% F_{MSY}	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91
	2015	Projection	399	3,318	0.14	199	1,713	0.14	460	3,997	0.14	332	3,027	0.14
	2016	Projection	573	4,693	0.14	306	2,570	0.14	701	6,083	0.14	419	3,837	0.14
	2017	Projection	776	6,469	0.14	434	3,645	0.14	1,016	8,828	0.14	509	4,721	0.14
$F_{rebuild}$	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91
	2015	Projection	176	3,361	0.06	***0***	***1,749***	***0.00***	203	4,047	0.06	***0***	***3,093***	***0.00***
	2016	Projection	266	4,968	0.06	***0***	***2,818***	***0.00***	324	6,401	0.06	***0***	***4,190***	***0.00***
	2017	Projection	374	7,074	0.06	***0***	***4,236***	***0.00***	485	9,569	0.06	***0***	***5,414***	***0.00***
$F_{no\ action}$	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91
	2015	Projection	1,550	3,057	0.64	1,550	1,356	1.61	1,550	3,756	0.54	1,550	2,736	0.80

Figures

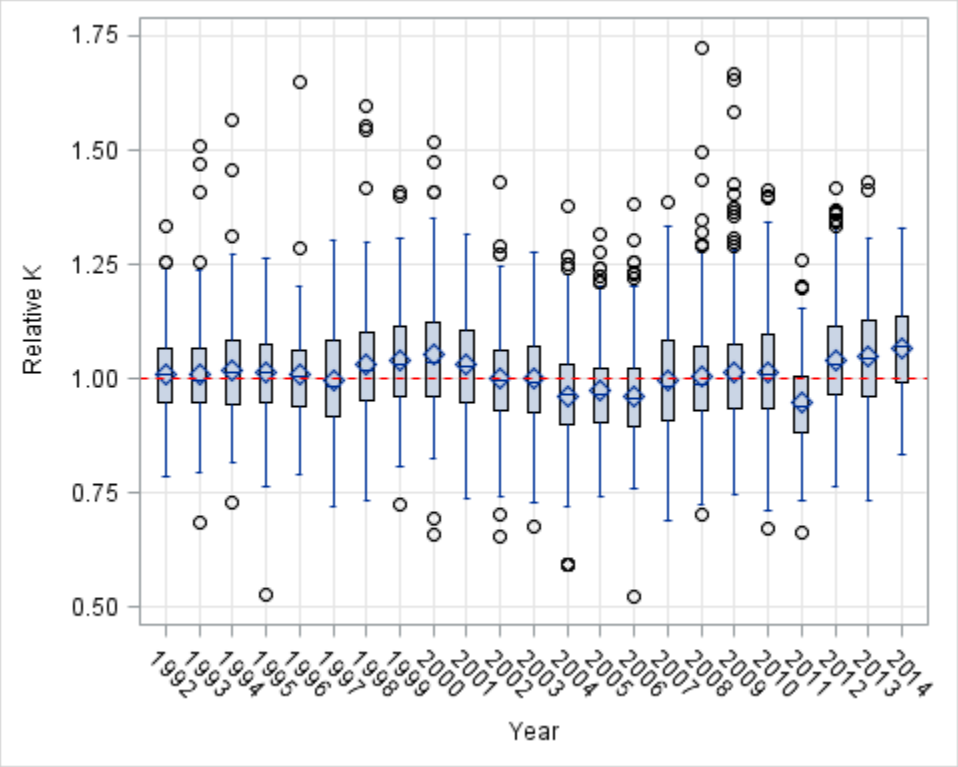

Figure A1. Annual trends in relative condition factor of Gulf of Maine Atlantic cod (*Gadus morhua*) based on length and weight data collected from the NEFSC bottom trawl survey.

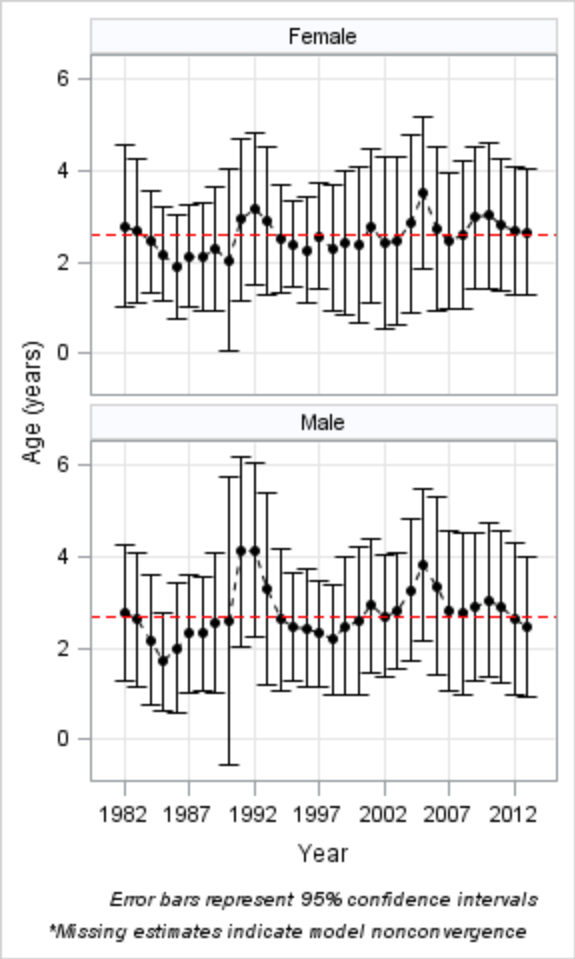

Figure A2. Annual average age-at-50% maturity ($A_{50\%}$) and corresponding 95% confidence intervals for female and male Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013. Average maturity has been estimated from data collected from the Northeast Fisheries Science Center (NEFSC) spring bottom trawl survey.

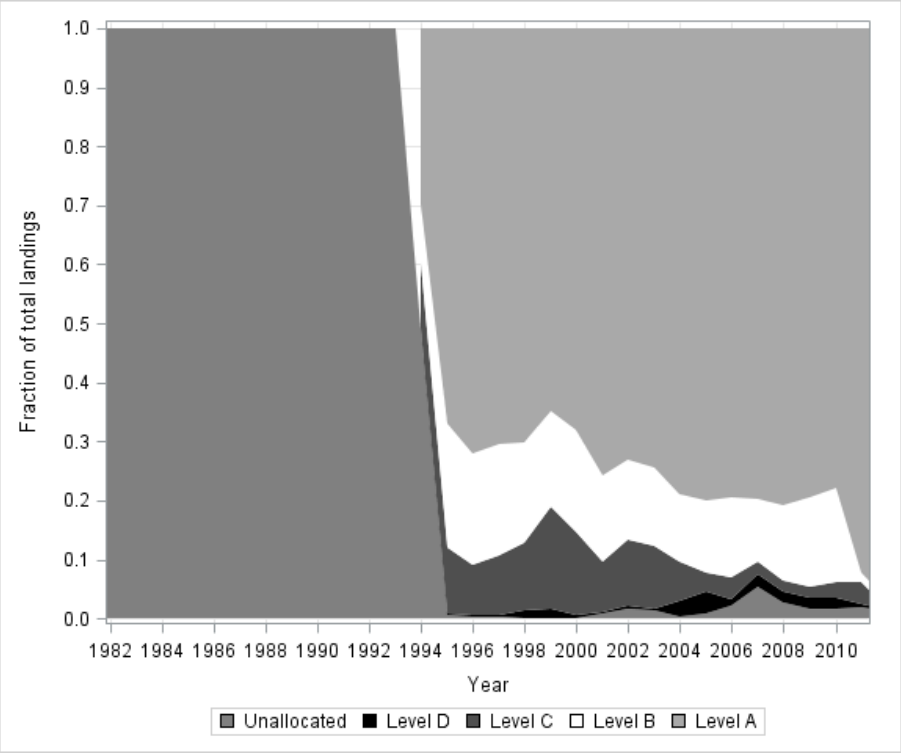

Figure A3. Fraction of the Gulf of Maine Atlantic cod (*Gadus morhua*) commercial landings by allocation level between 1982 and 2013. Prior to 1994 landings were allocated based on a port interview process. From 1994 onward landings were allocated to statistical area and gear type based on a standardized allocation scheme (see NEFSC, 2013 for additional details).

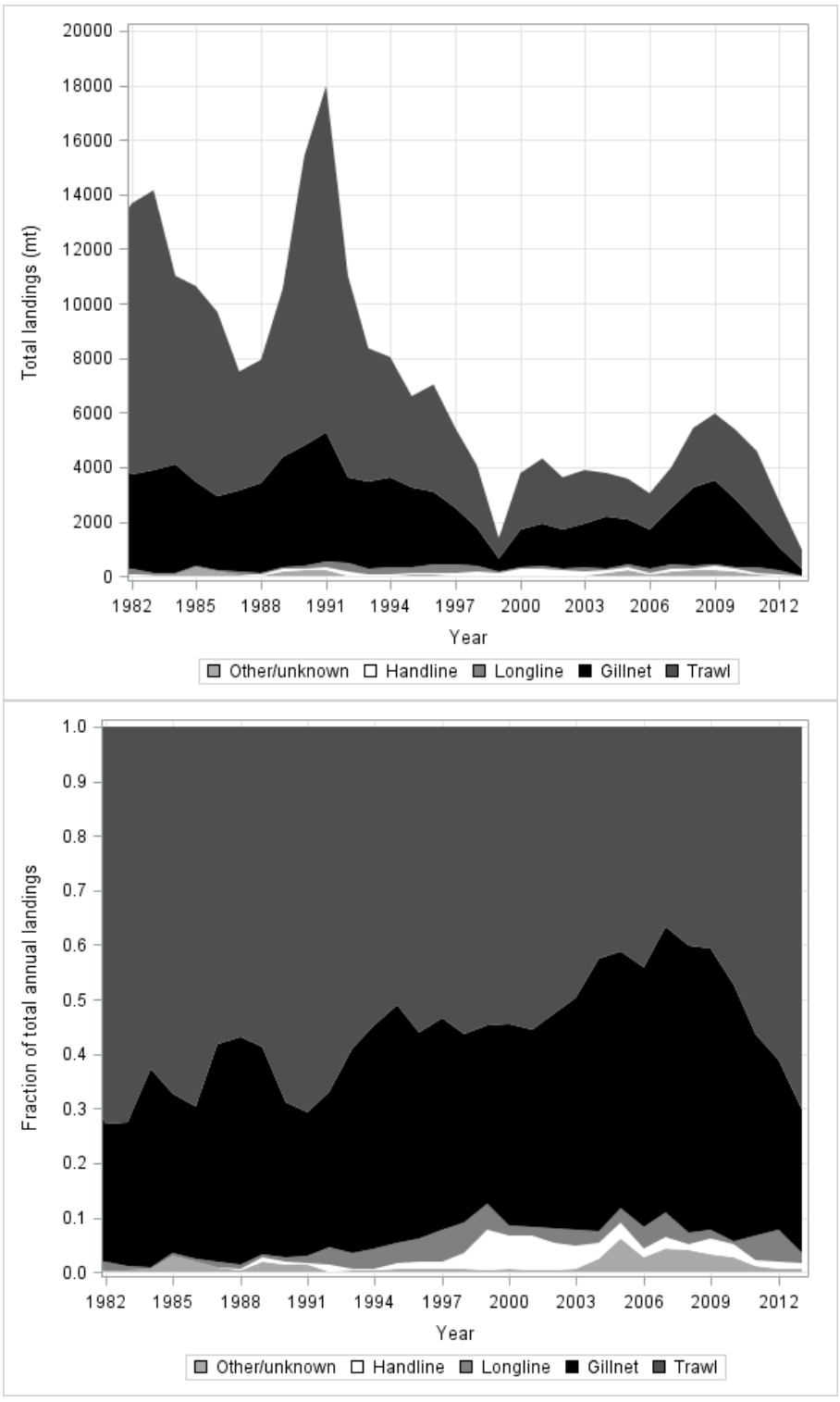

Figure A4. Total (top) and fractional (as a fraction of the total, bottom) commercial landings of Gulf of Maine Atlantic cod (*Gadus morhua*) by gear type from 1982 to 2013.

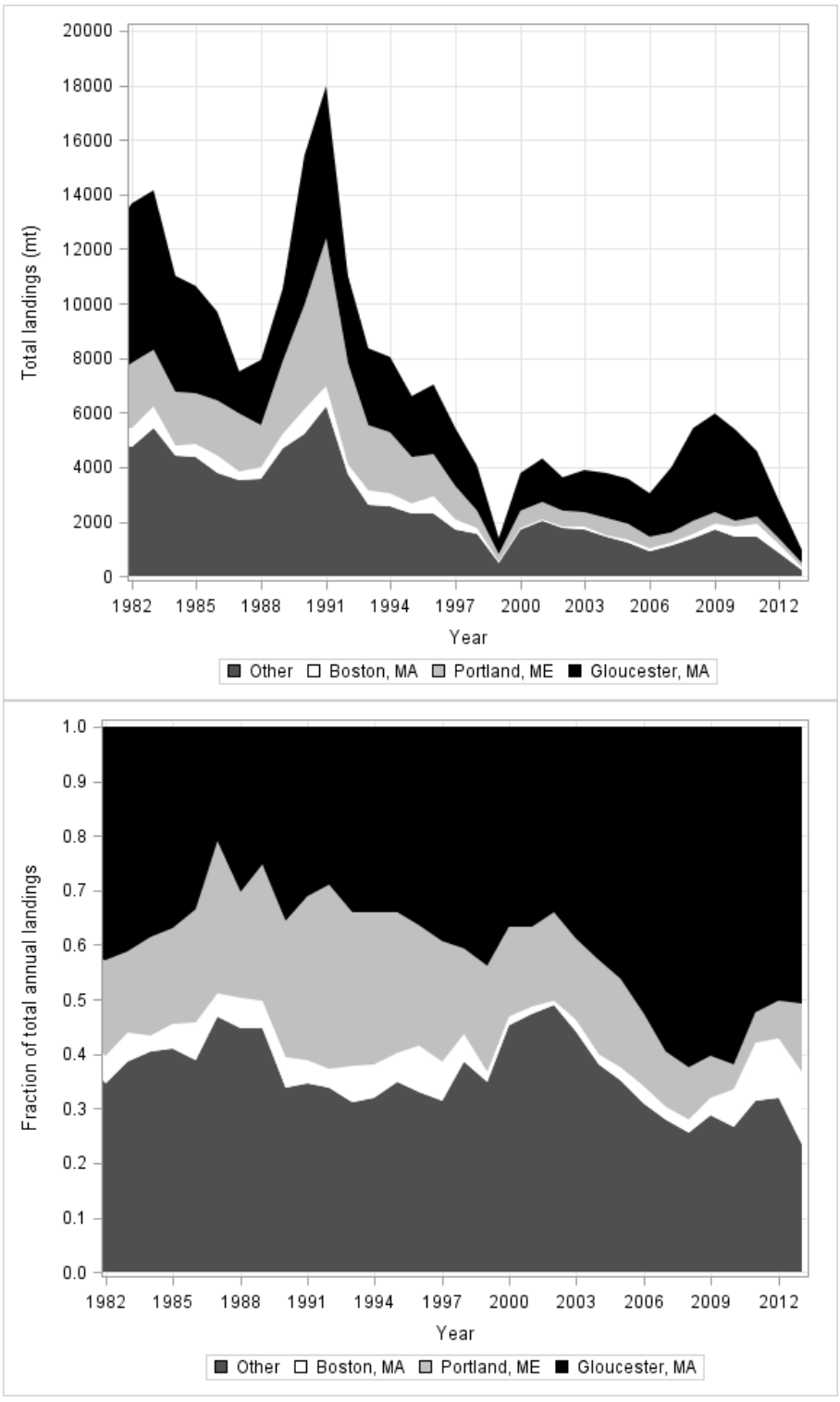

Figure A5. Total (top) and fractional (as a fraction of the total, bottom) commercial landings of Gulf of Maine Atlantic cod (*Gadus morhua*) by port from 1982 to 2013.

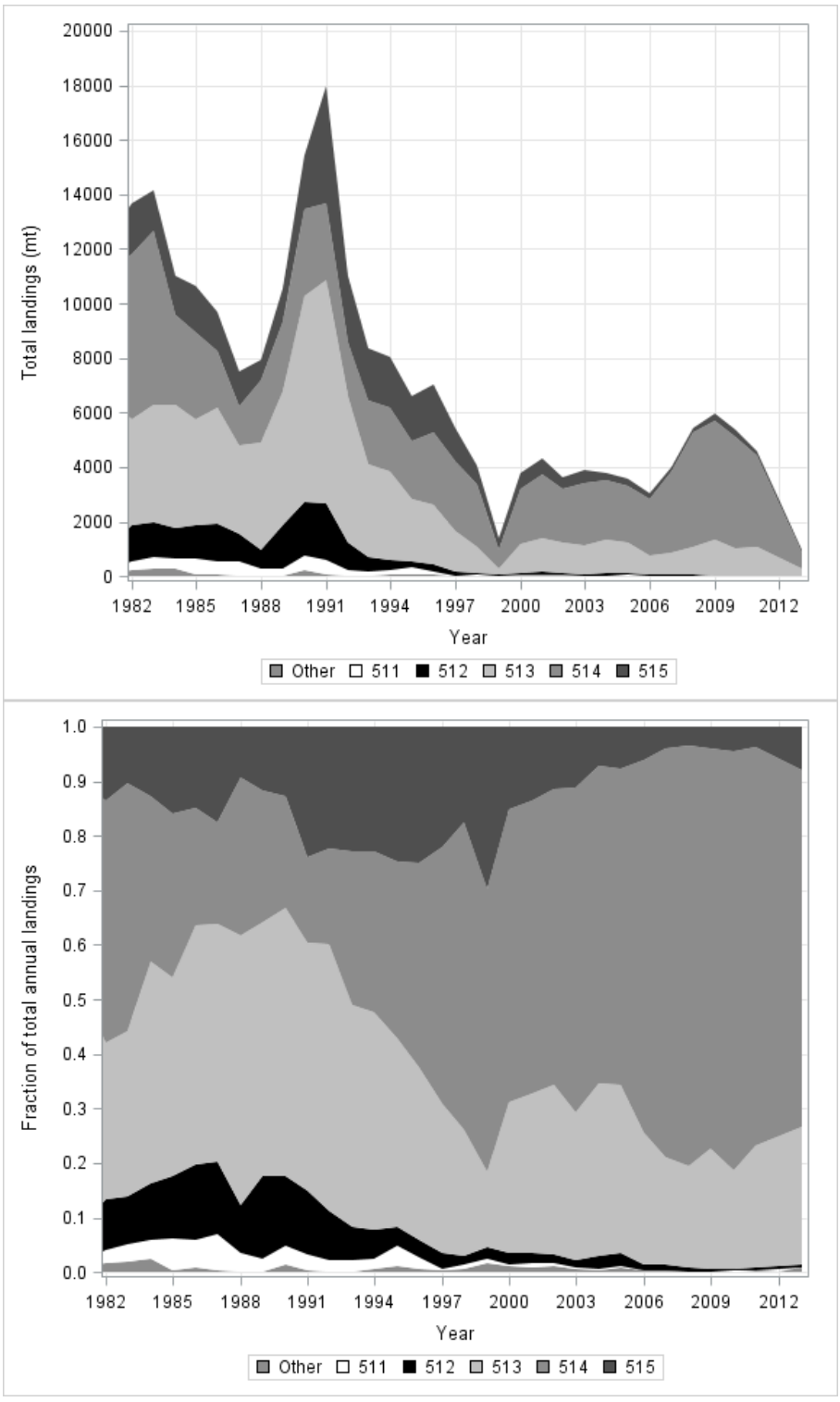

Figure A6. Total (top) and fractional (as a fraction of the total, bottom) commercial landings of Gulf of Maine Atlantic cod (*Gadus morhua*) by statistical area from 1982 to 2013.

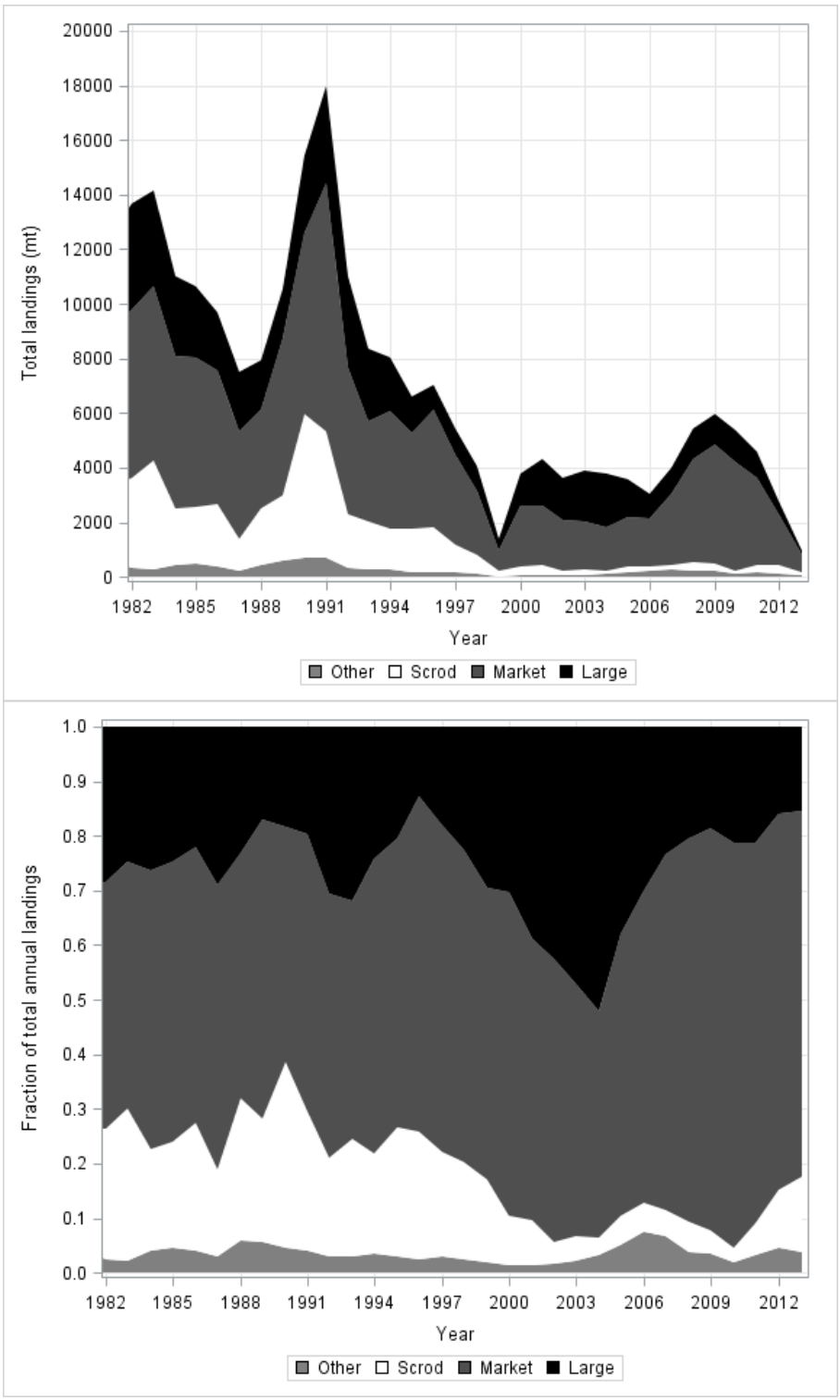

Figure A7. Total (top) and fractional (as a fraction of the total, bottom) commercial landings of Gulf of Maine Atlantic cod (*Gadus morhua*) by market category from 1982 to 2013.

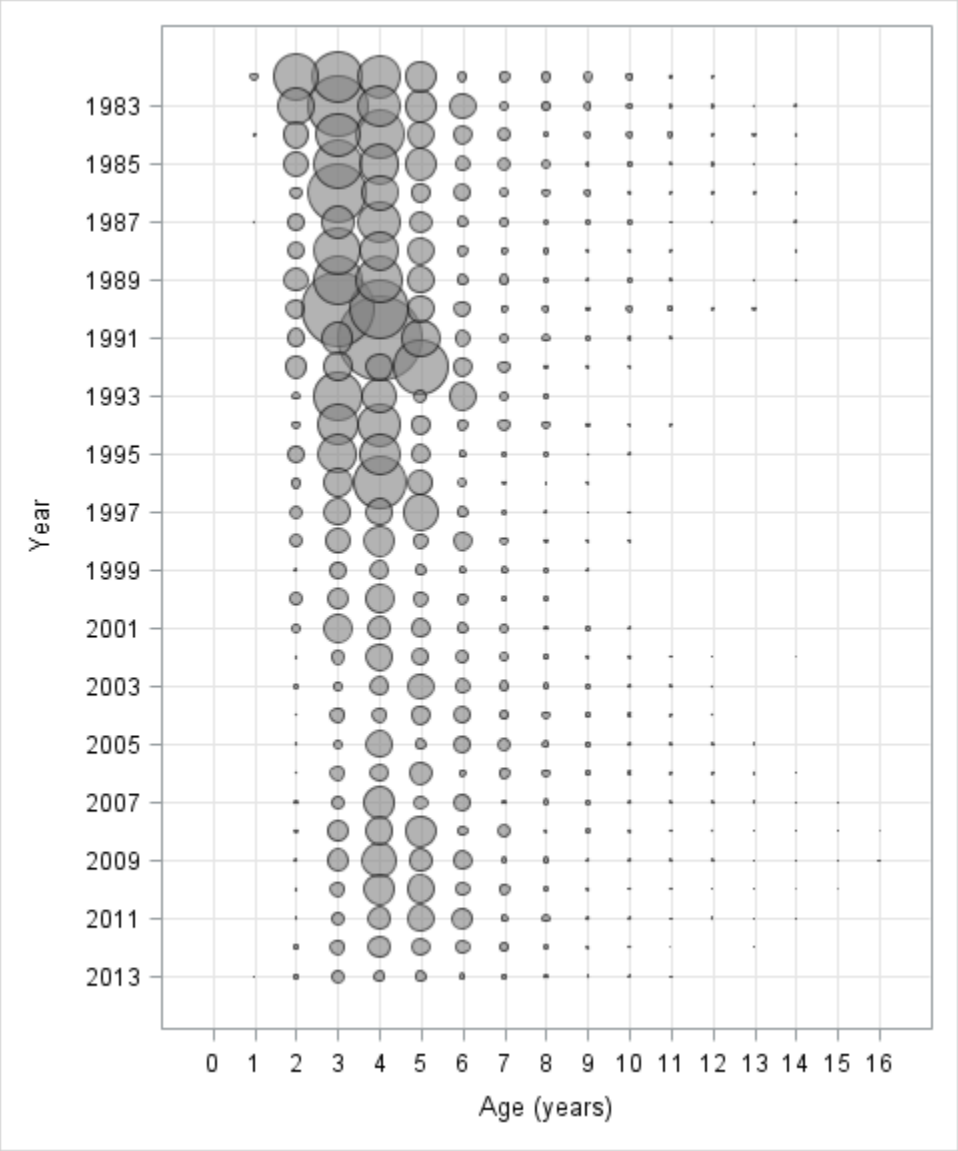

Figure A8. Commercial landings-at-age of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013. *Note that scale has been adjusted to maximize visibility of catch-at-age (i.e., size of bubbles is not comparable between plots).*

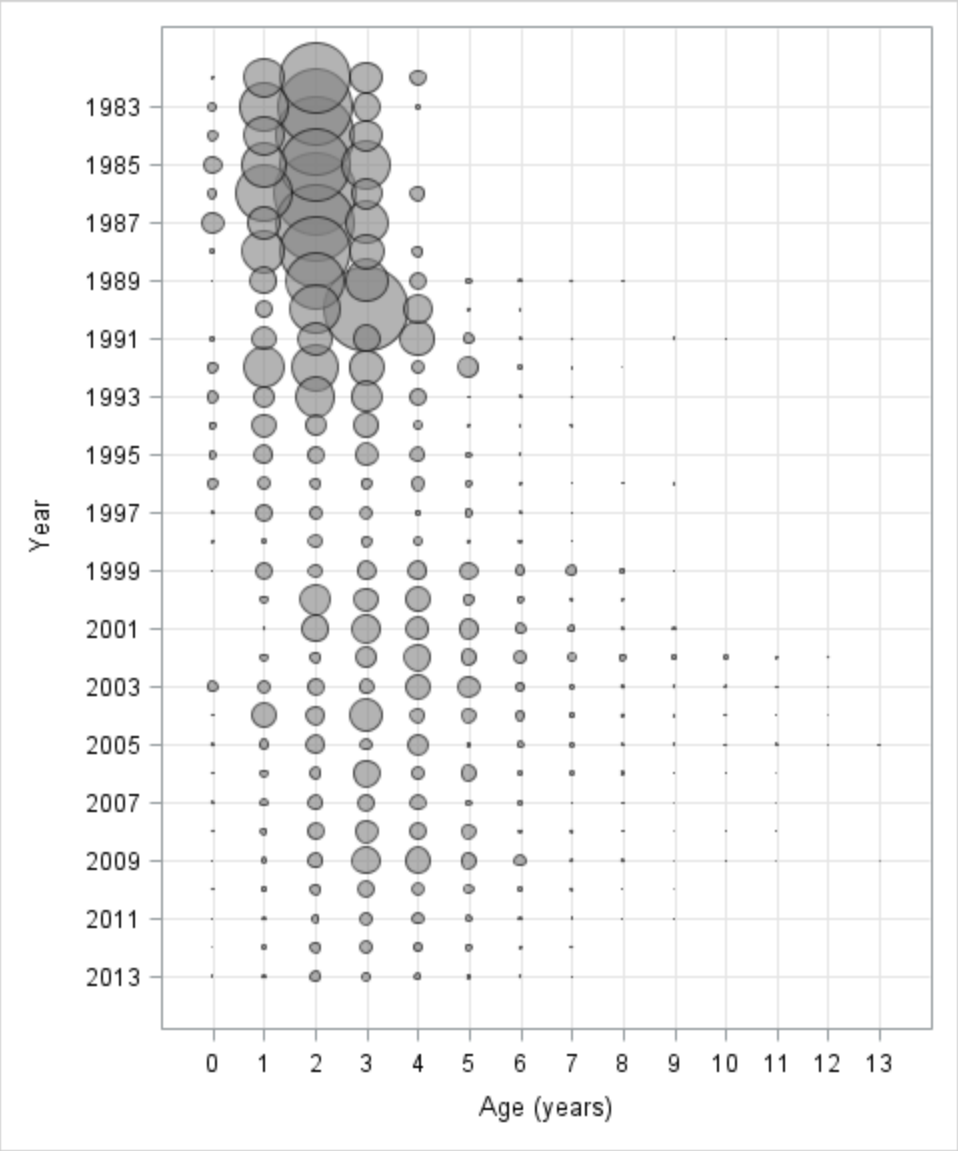

Figure A9. Commercial discards-at-age of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013. *Note that scale has been adjusted to maximize visibility of catch-at-age (i.e., size of bubbles is not comparable between plots)*.

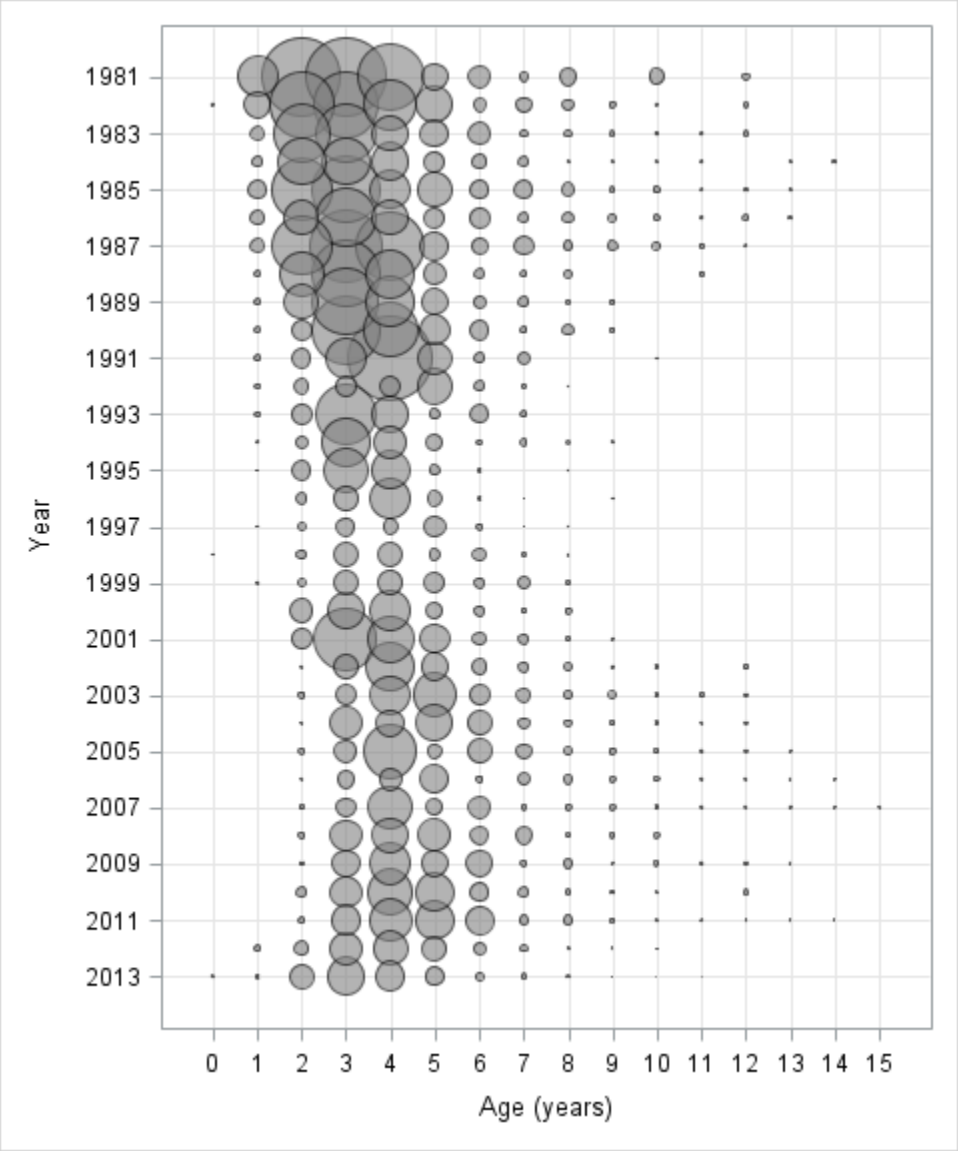

Figure A10. Recreational landings-at-age of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1981 to 2013. *Note that scale has been adjusted to maximize visibility of catch-at-age (i.e., size of bubbles is not comparable between plots).*

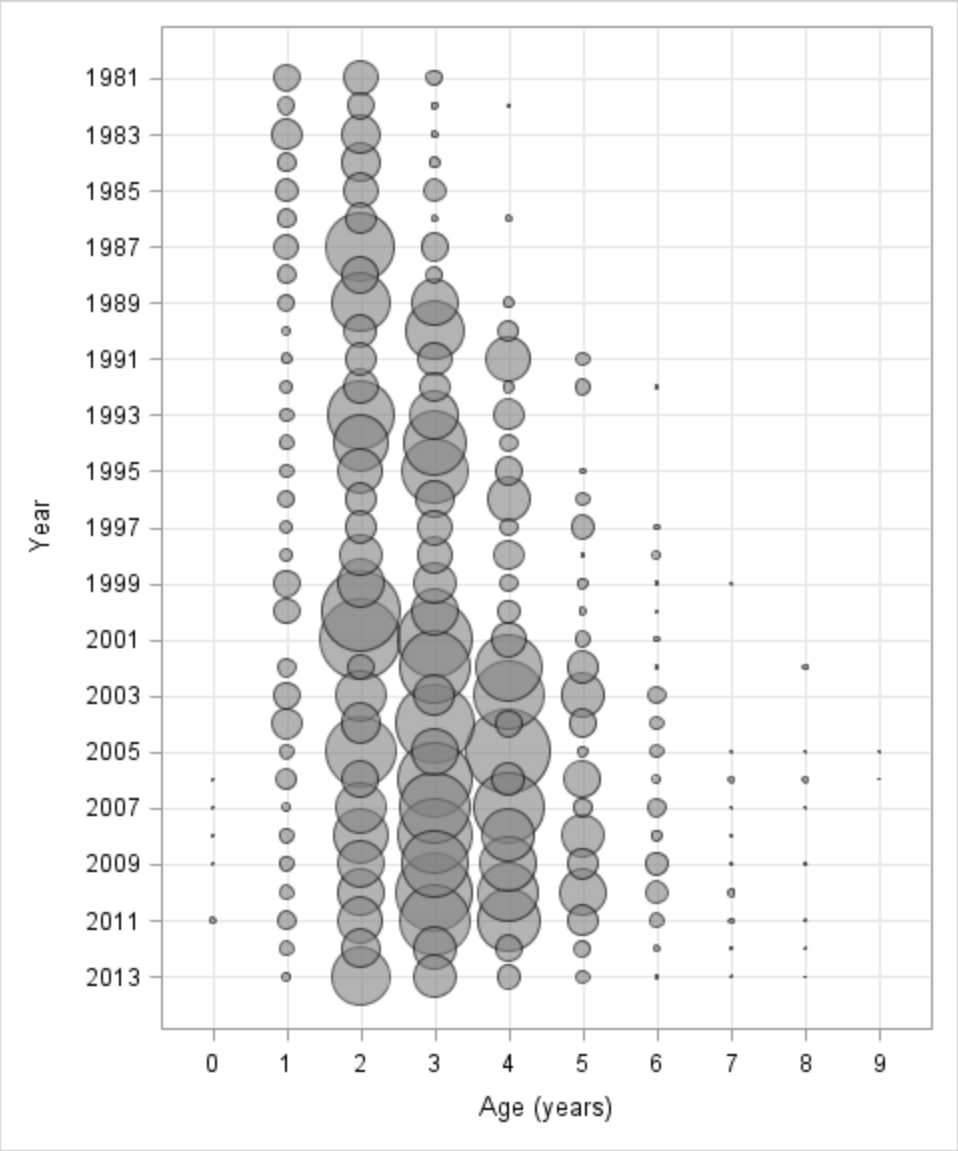

Figure A11. Recreational discards-at-age of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1981 to 2013. *Note that scale has been adjusted to maximize visibility of catch-at-age (i.e., size of bubbles is not comparable between plots).*

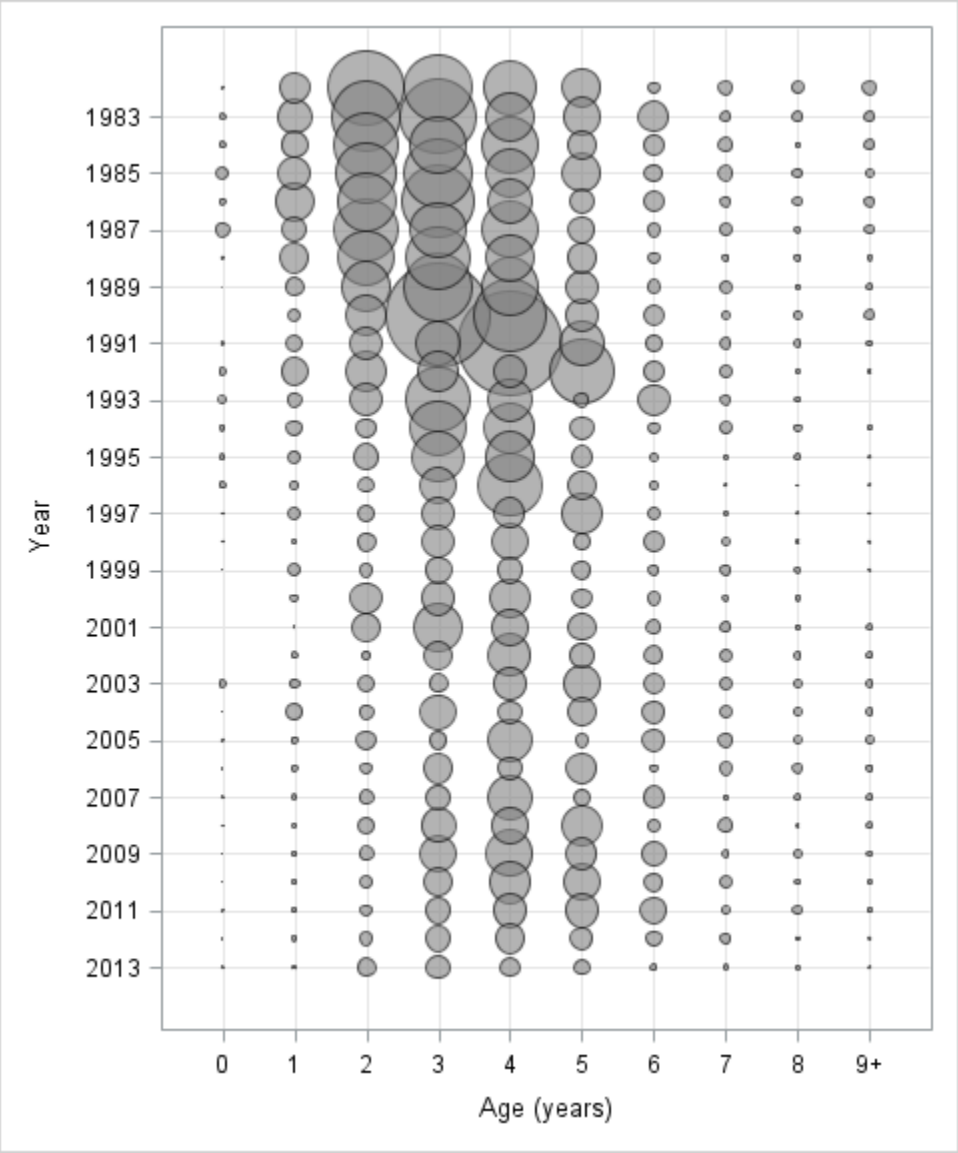

Figure A12. Total catch-at-age of Gulf of Maine Atlantic cod (*Gadus morhua*) from 1981 to 2013. *Only ages 1 through the 9^{+}group are used as assessment model inputs. The scale has been adjusted to maximize visibility of catch-at-age (i.e., size of bubbles is not comparable between plots).*

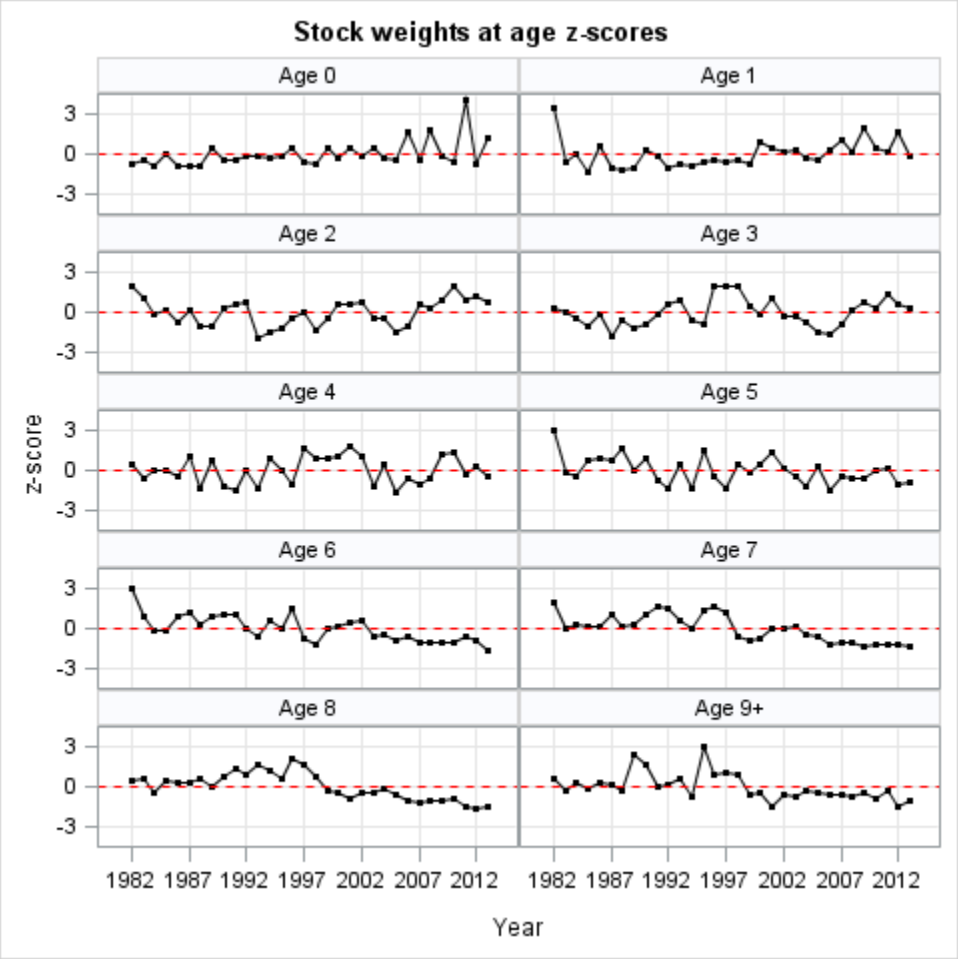

Figure A13. Average stock weights-at-age of ages 0 to 9^{+} Gulf of Maine Atlantic cod (*Gadus morhua*) from 1982 to 2013. See NEFSC (2013) for a full description of the methods used to determine stock weights. Average weights are presented as z-scores ([*x*-μ]/σ). *Only ages 1 through the* 9^{+}*group are used as assessment model inputs.*

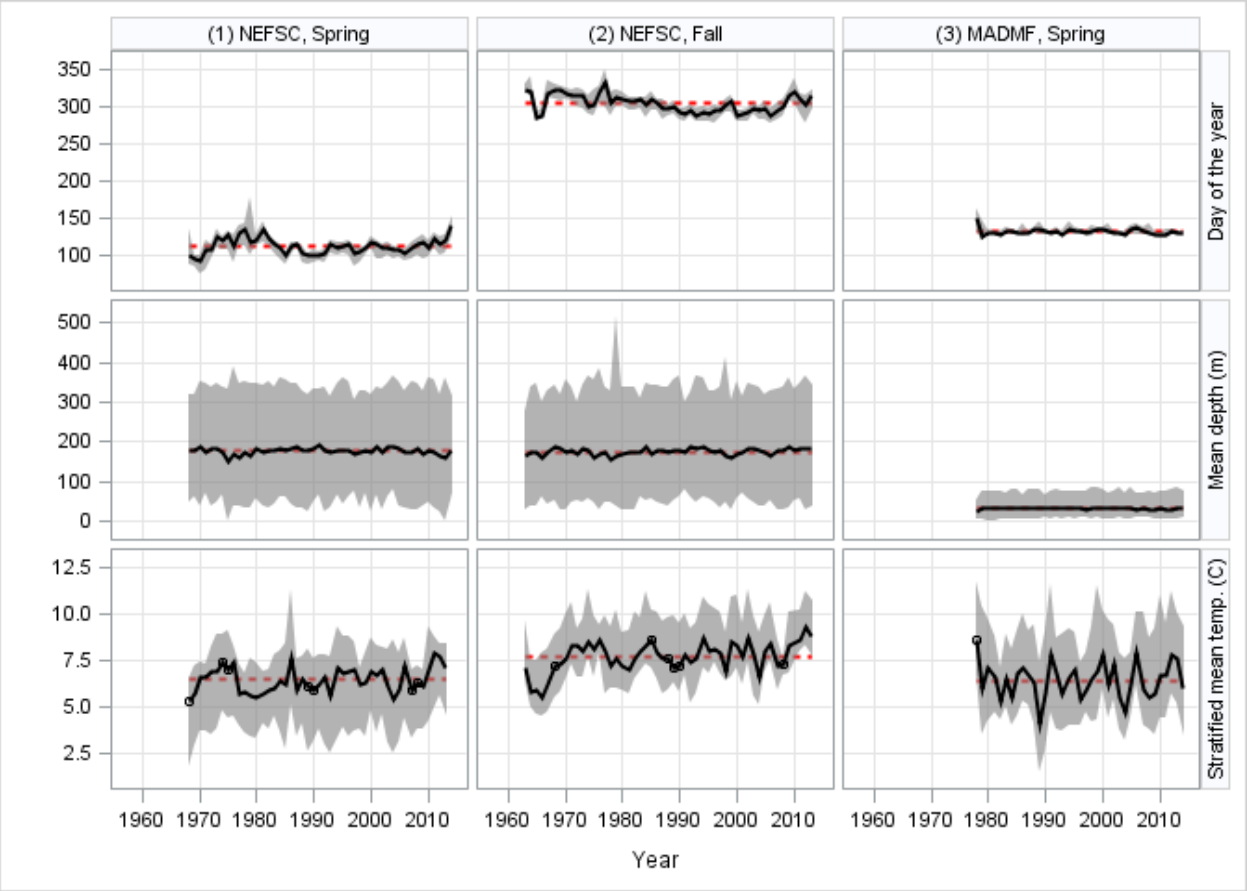

Figure A14. Mean day of the year of sampling in the Gulf of Maine by each of the three ongoing regional bottom trawl surveys used in the Gulf of Maine Atlantic cod (*Gadus morhua*) assessment: Northeast Fisheries Scienc Center (NEFSC) spring and fall bottom trawl surveys and the Massachusetts Division of Marine Fisheries (MADMF) inshore spring survey. Grey bands indicate the minimum and maximum for each survey/year. Day of the year is expressed as Julian days (e.g., January 1 is day 1 and December 31 is day 365/66). Years marked with circles in the mean temperature plot indicate years when not all survey stratum were sampled and therefore the mean temperature may not be representative of the entire survey area. *Note that bottom temperature data are not yet available for the NEFSC spring 2014 survey.*

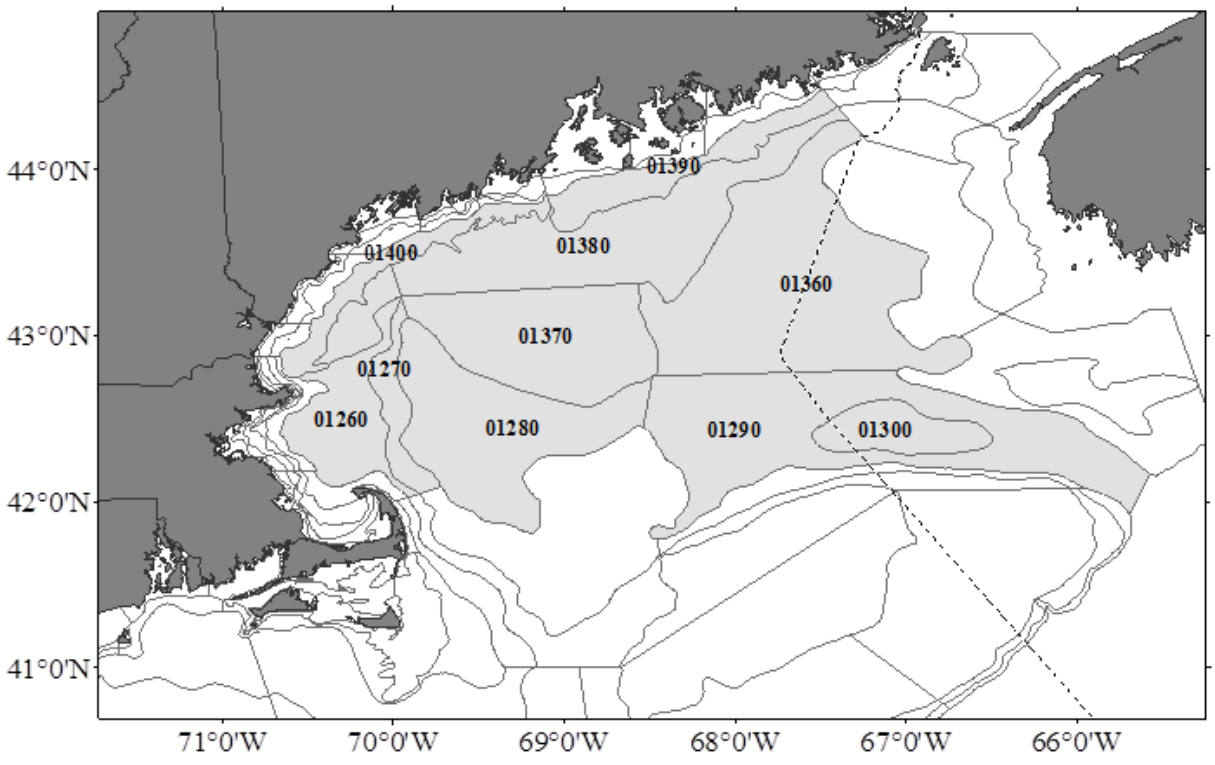

Figure A15. Map of the Northeast Fisheries Science Center (NEFSC) bottom trawl offshore survey strata used in the Gulf of Maine Atlantic cod (*Gadus morhua*) stock assessment (light grey).

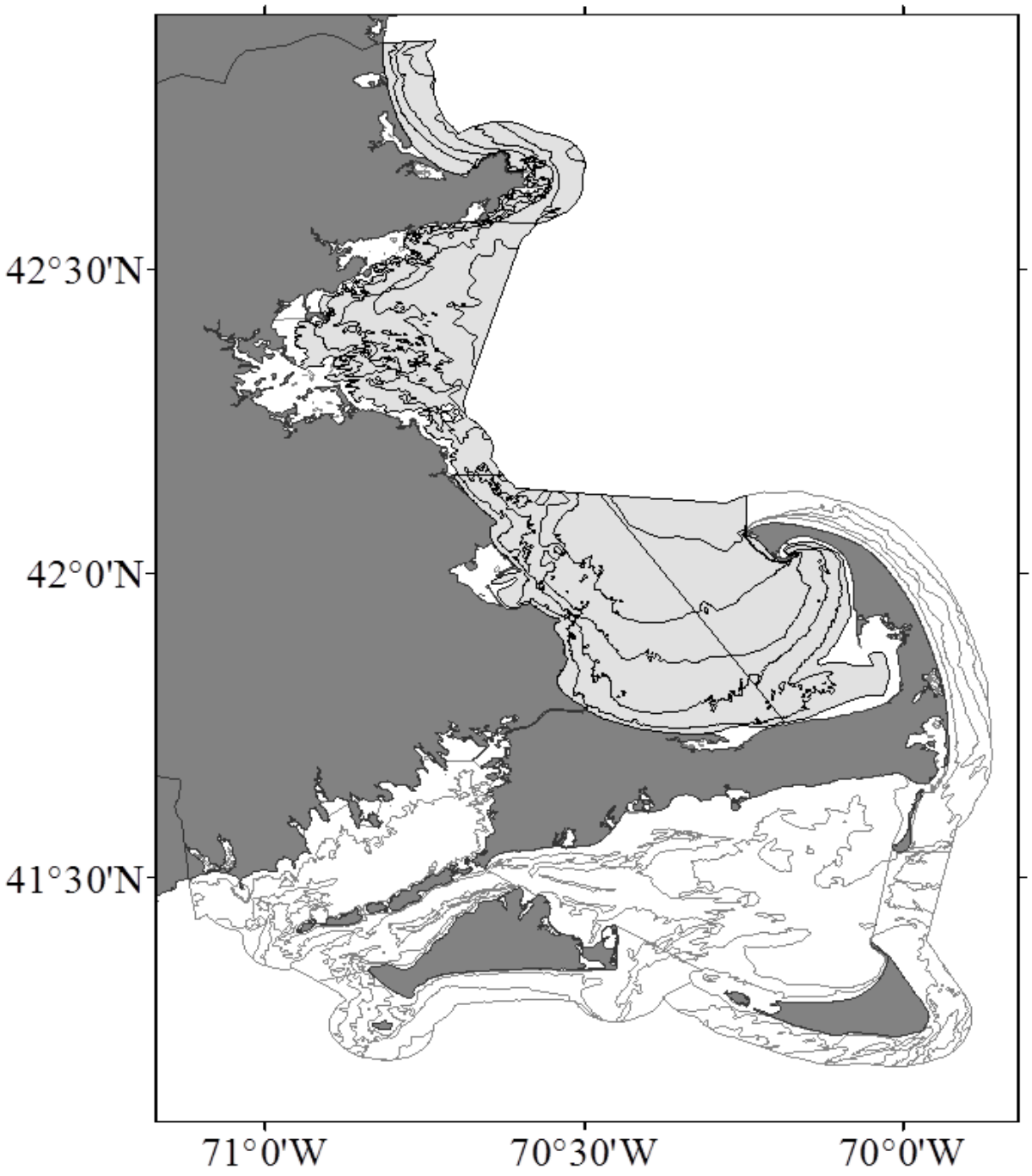

Figure A16. Map of the Massachusetts Deparment of Marine Fisheries (MADMF) bottom trawl survey strata used in the Gulf of Maine Atlantic cod (*Gadus morhua*) stock assessment (light grey).

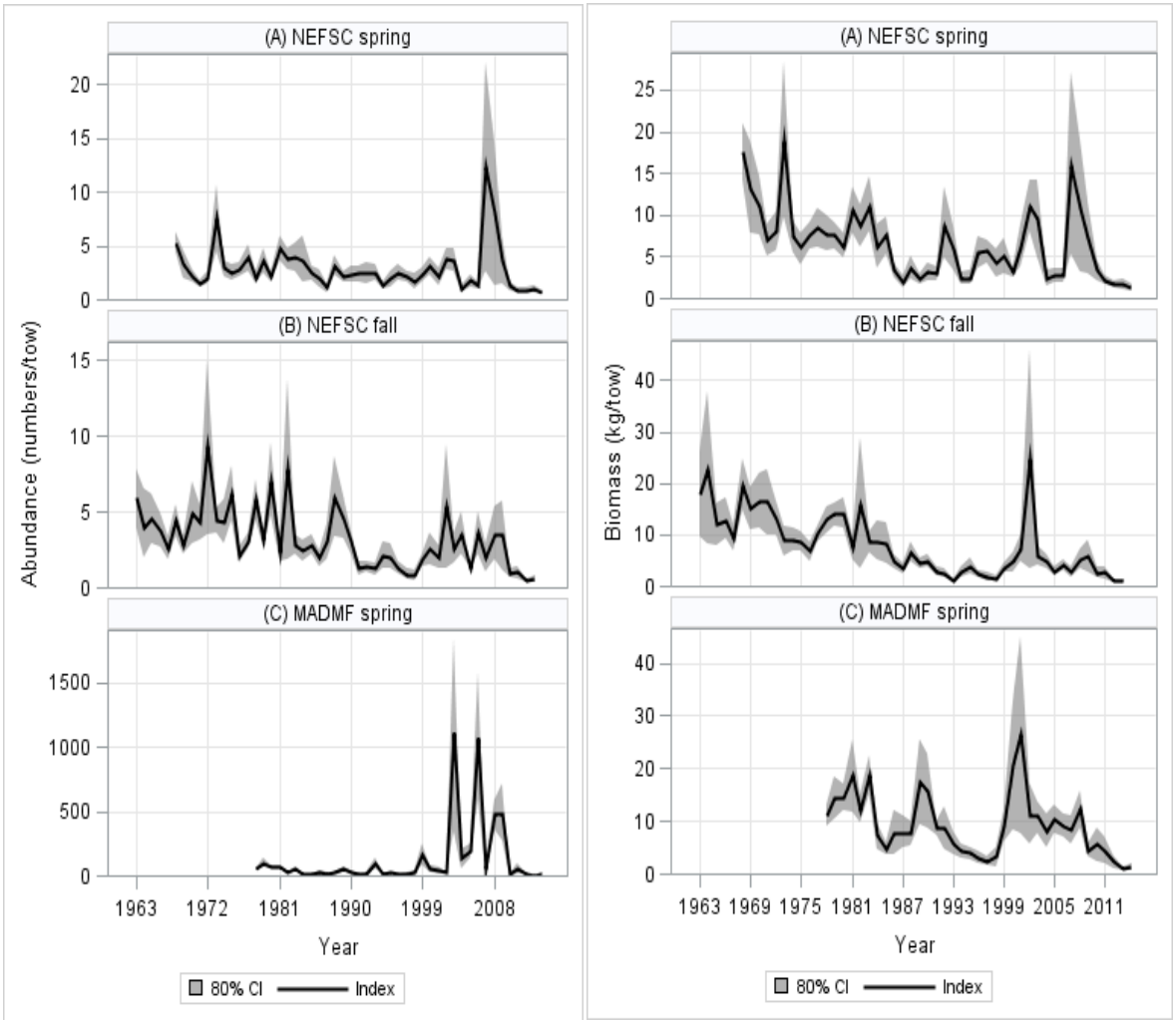

Figure A17. Northeast Fisheries Scienc Center (NEFSC) spring and fall bottom trawl surveys and the Massachusetts Division of Marine Fisheries (MADMF) inshore spring survey abundance (left) and biomass (right) indices for Gulf of Maine Atlantic cod (*Gadus morhua*) from 1963 to 2014. ***Note, the NEFSC spring survey did not begin until 1968 and the MADMF spring survey until 1978. The NEFSC fall 2014 survey has not been conducted at the time of this report.***

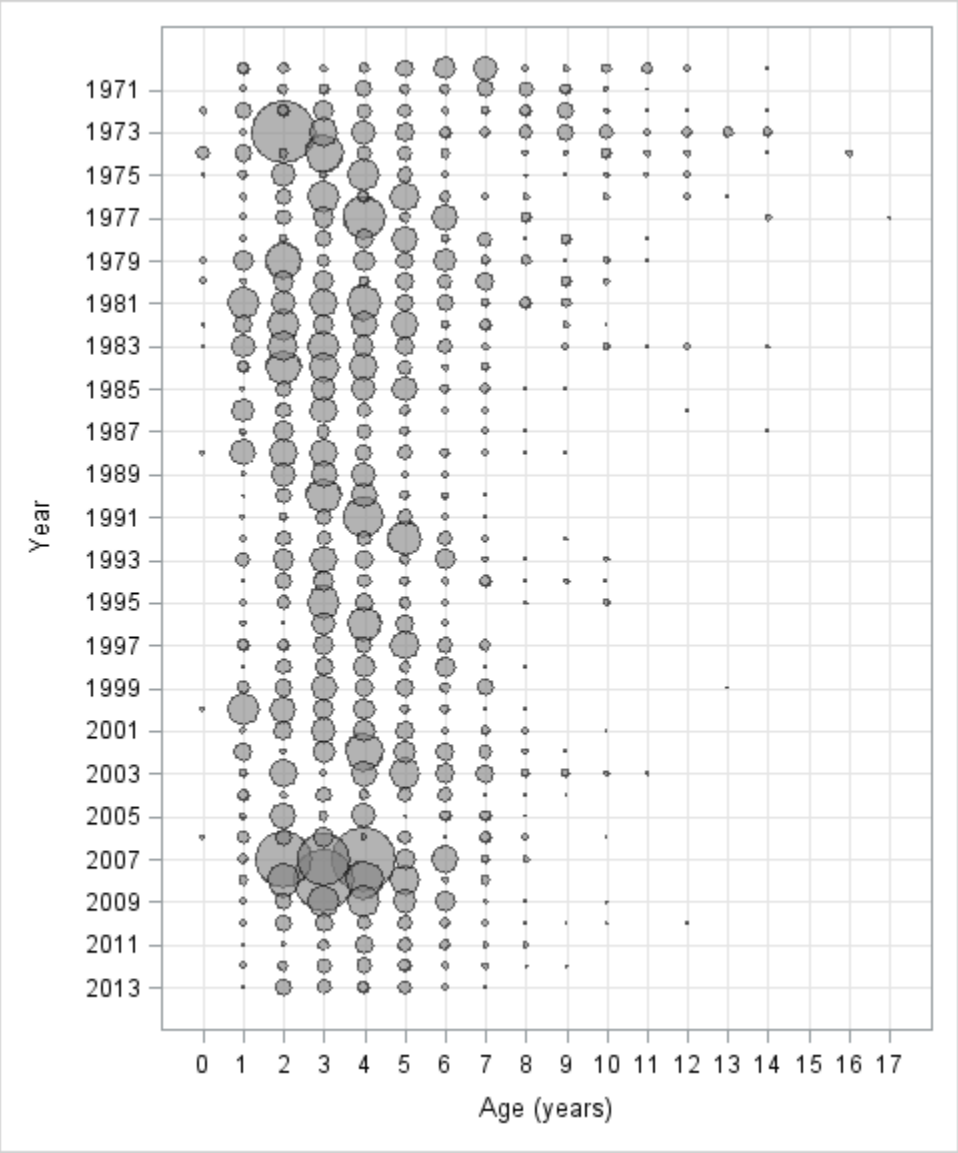

Figure A18. Gulf of Maine Atlantic cod (*Gadus morhua*) abundance (numbers/tow) indices-at-age from Northeast Fisheries Science Center (NEFSC) spring bottom trawl survey from 1970 to 2013. *Note that scale has been adjusted to maximize visibility of indices-at-age (i.e., size of bubbles is not comparable between plots).*

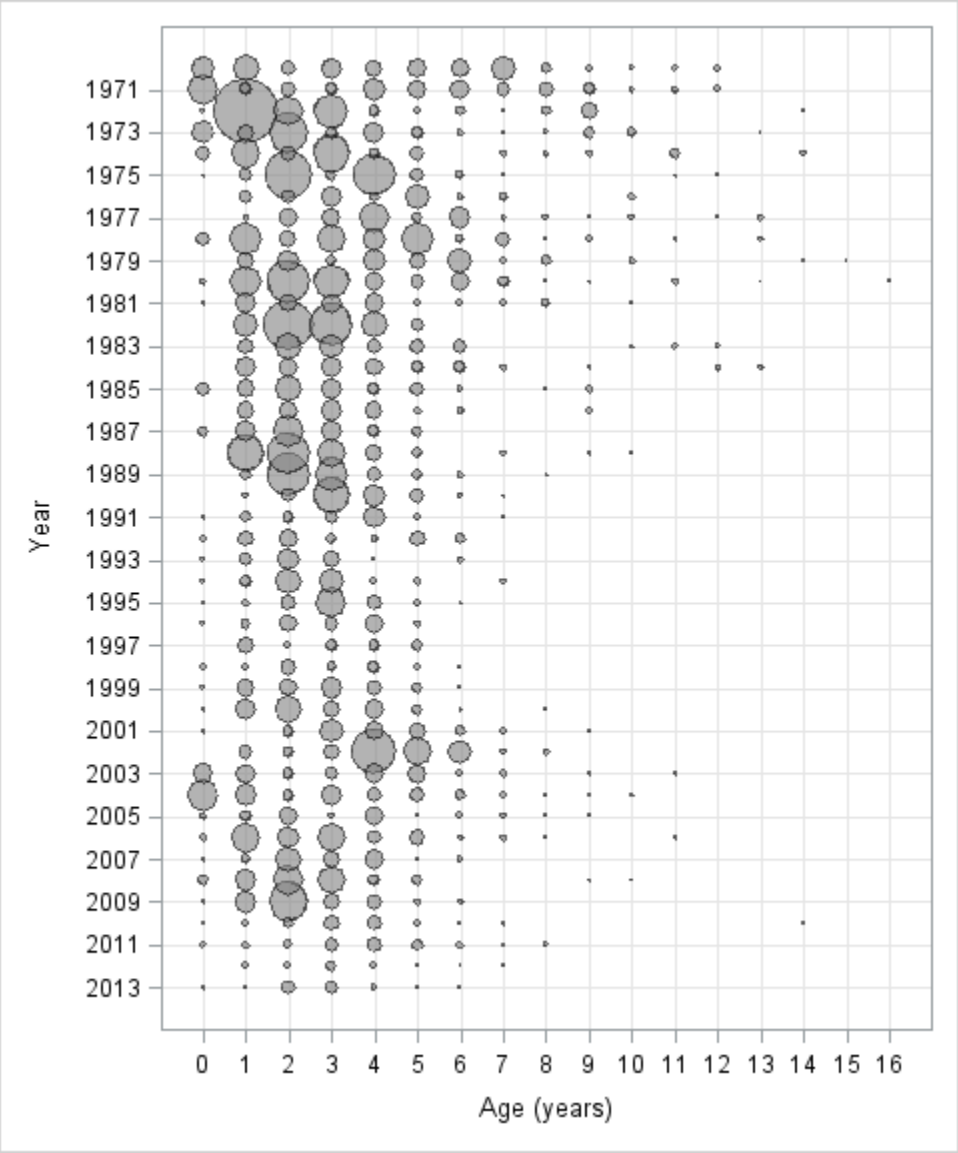

Figure A19. Gulf of Maine Atlantic cod (*Gadus morhua*) abundance (numbers/tow) indices-at-age from Northeast Fisheries Science Center (NEFSC) fall bottom trawl survey from 1970 to 2013. *Note that scale has been adjusted to maximize visibility of indices-at-age (i.e., size of bubbles is not comparable between plots).*

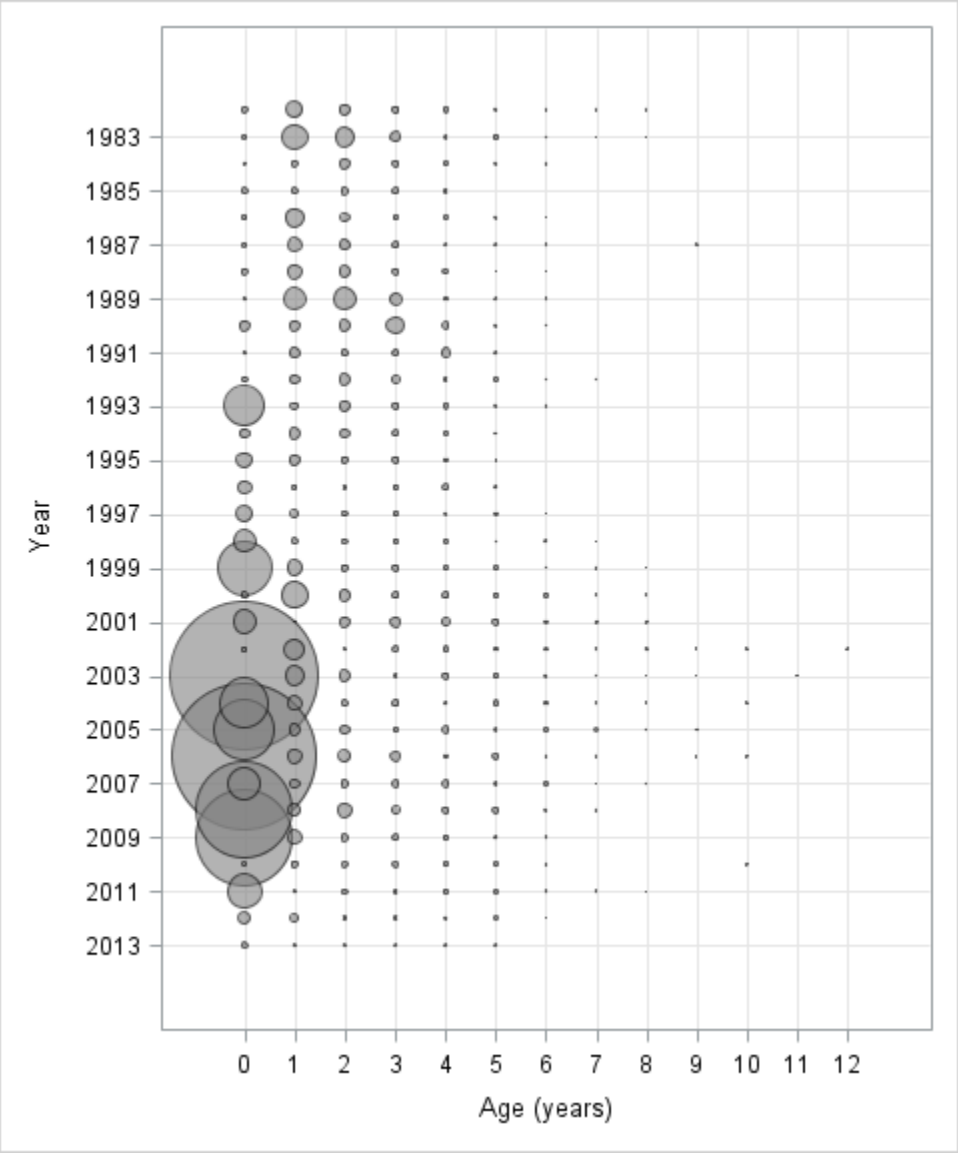

Figure A20. Gulf of Maine Atlantic cod (*Gadus morhua*) abundance (numbers/tow) indices-at-age from Massachusetts Division of Marine Fisheries (MADMF) spring inshore trawl survey from 1970 to 2013. *Note that there was insufficient age information available from the MADMF spring survey prior to 1982. The scale has been adjusted to maximize visibility of indices-at-age (i.e., size of bubbles is not comparable between plots).*

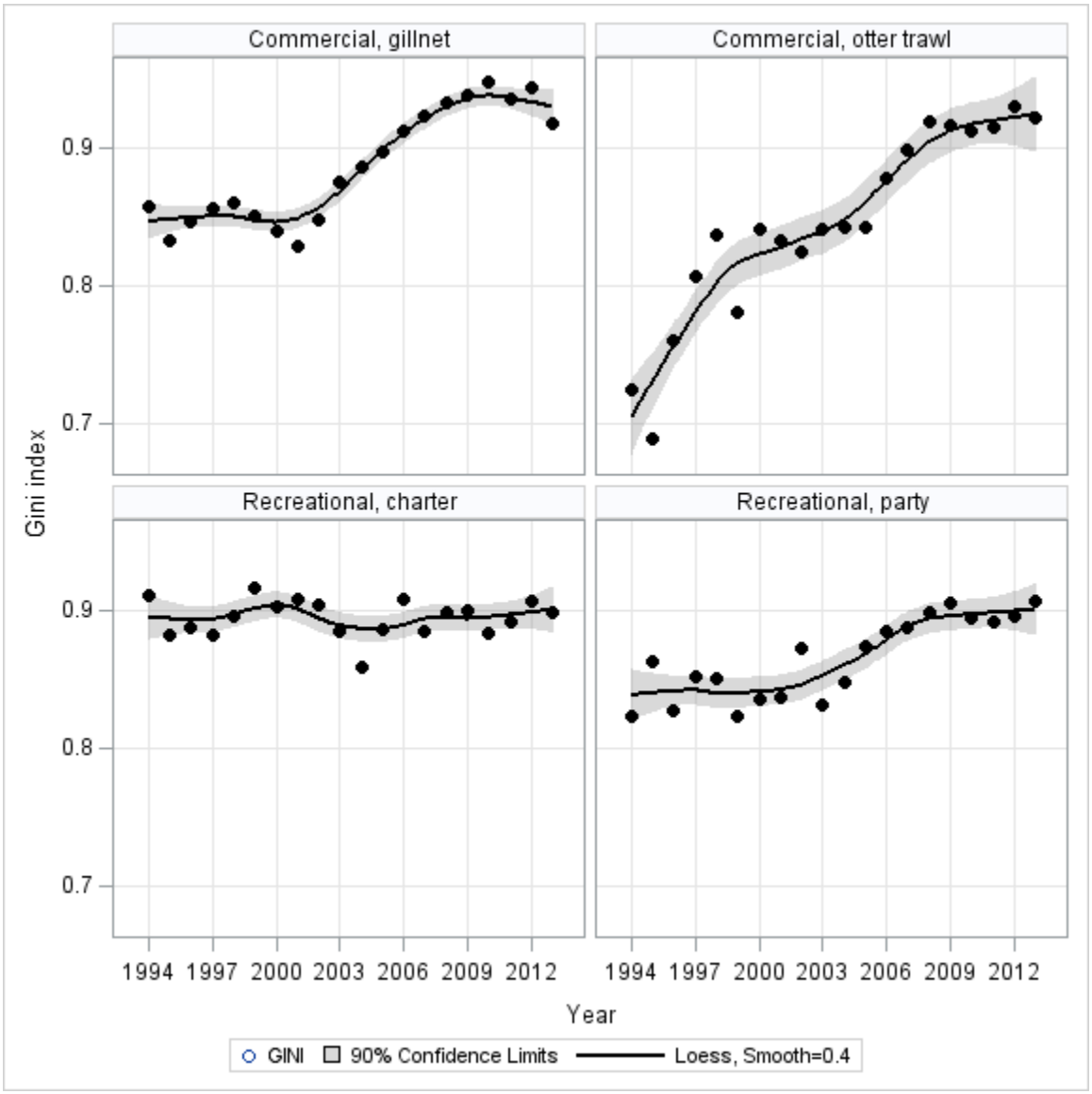

Figure A21. Gini indices of Gulf of Maine Atlantic cod (*Gadus morhua*) landings by the commercial otter trawl and sink gillnet fleets and the recreational party and charter fleets from 1994-2013. Indices are based on the spatial distribution of the retained catch reported on vessel trip reports.

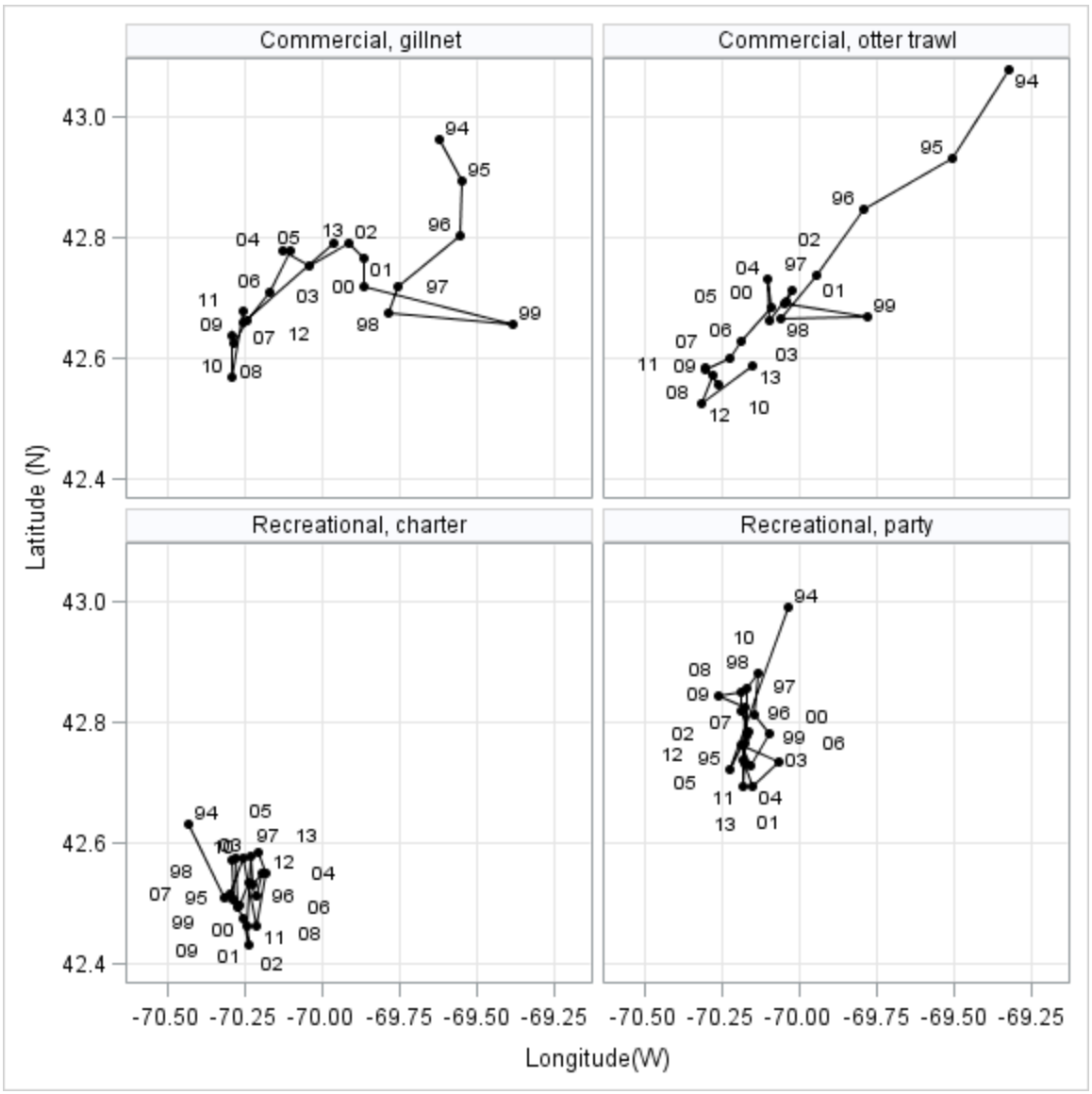

Figure A22. Landings-weighted mean location (centroid) of Gulf of Maine Atlantic cod (*Gadus morhua*) landings by the commercial otter trawl and sink gillnet fleets and the recreational party and charter fleets from 1994-2013. Centroids are based on the spatial distribution of the retained catch reported on vessel trip reports.

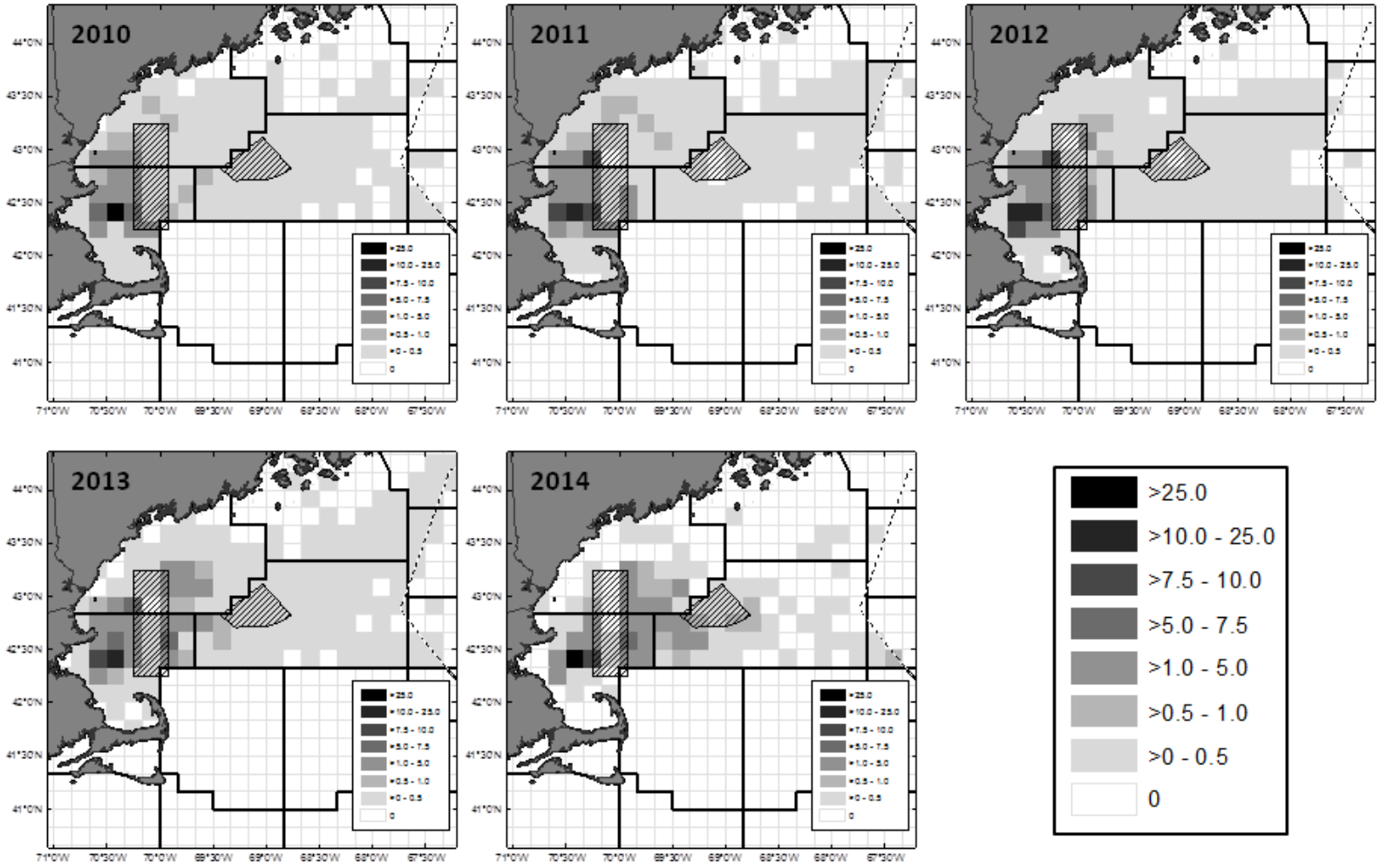

Figure A23. Fraction of total Gulf of Maine Atlantic cod (*Gadus morhua*) commercial landings by ten minute square based on retained catch reported on vessel trip reports. *Note that 2014 is a partial year (data through July 2014).*

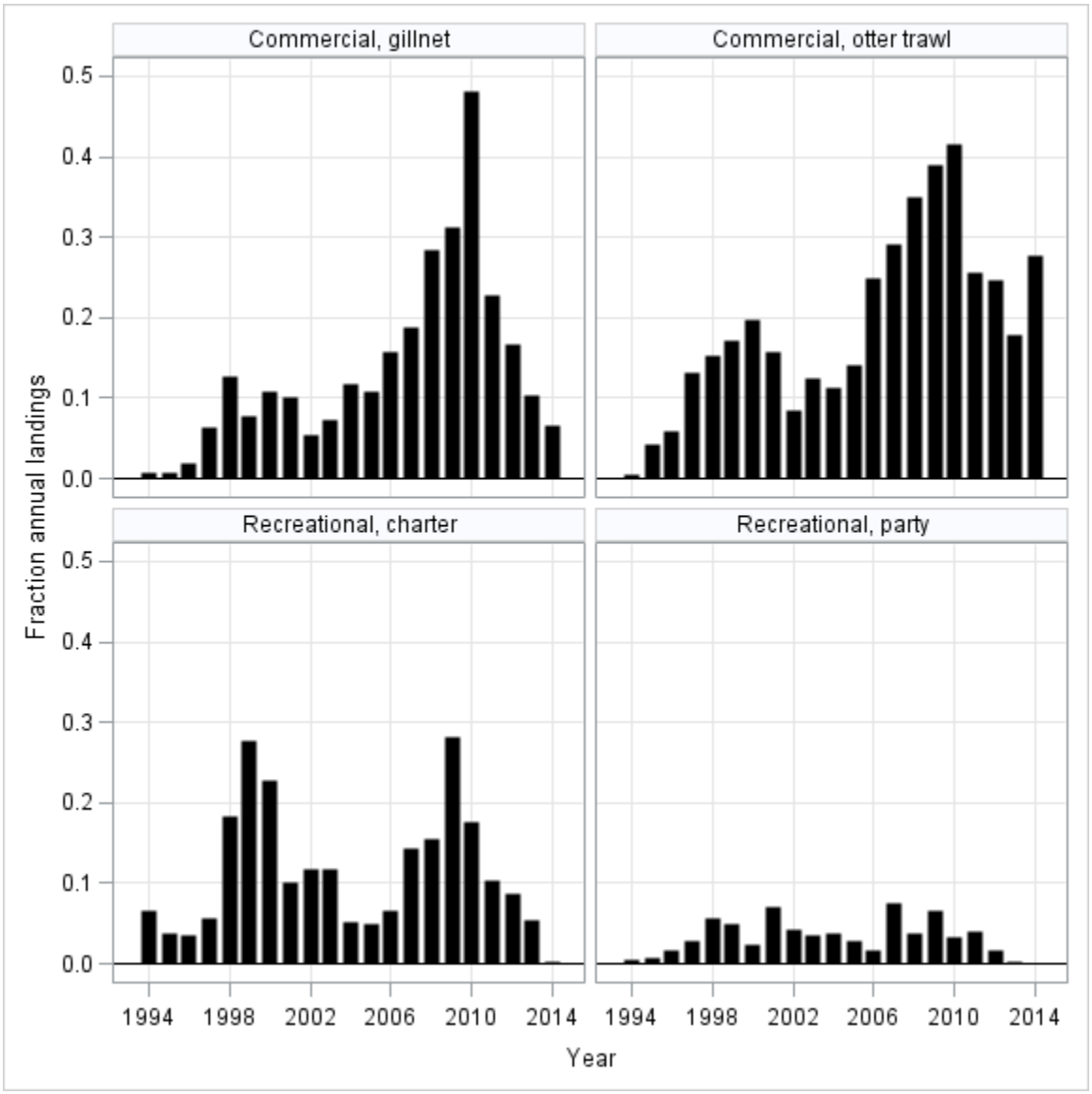

Figure A24. Fraction of total Gulf of Maine Atlantic cod (*Gadus morhua*) landings coming from ten minute square 427044 by fleet type and year. Plots are based on retained catch reported on vessel trip reports through July 2014.

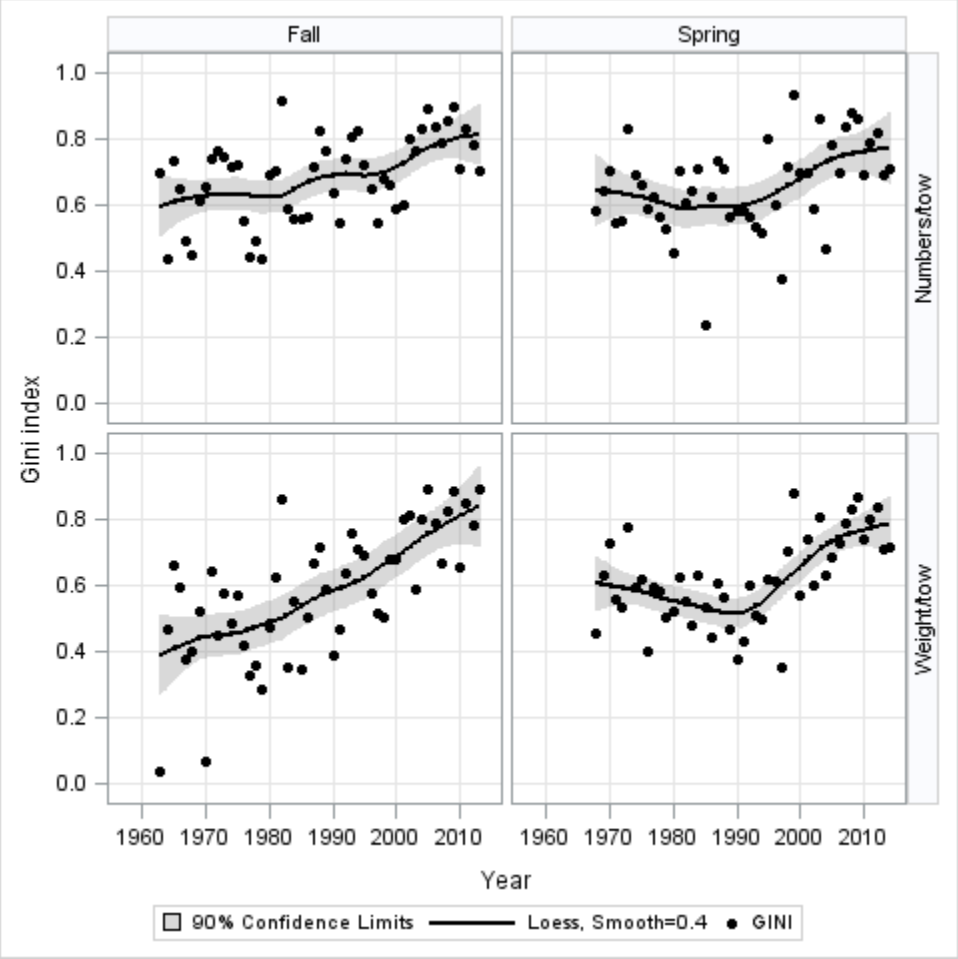

Figure A25. Gini indices for Gulf of Maine Atlantic cod (*Gadus morhua*) from the Northeast Fisheries Science Center (NEFSC) fall (top) and spring (bottom) bottom trawl surveys in terms of abundance (numbers/tow) and biomass (kg/tow). *Note that the NEFSC spring survey did not begin until 1968 and the 2014 fall survey had not been conducted at the time of this report.*

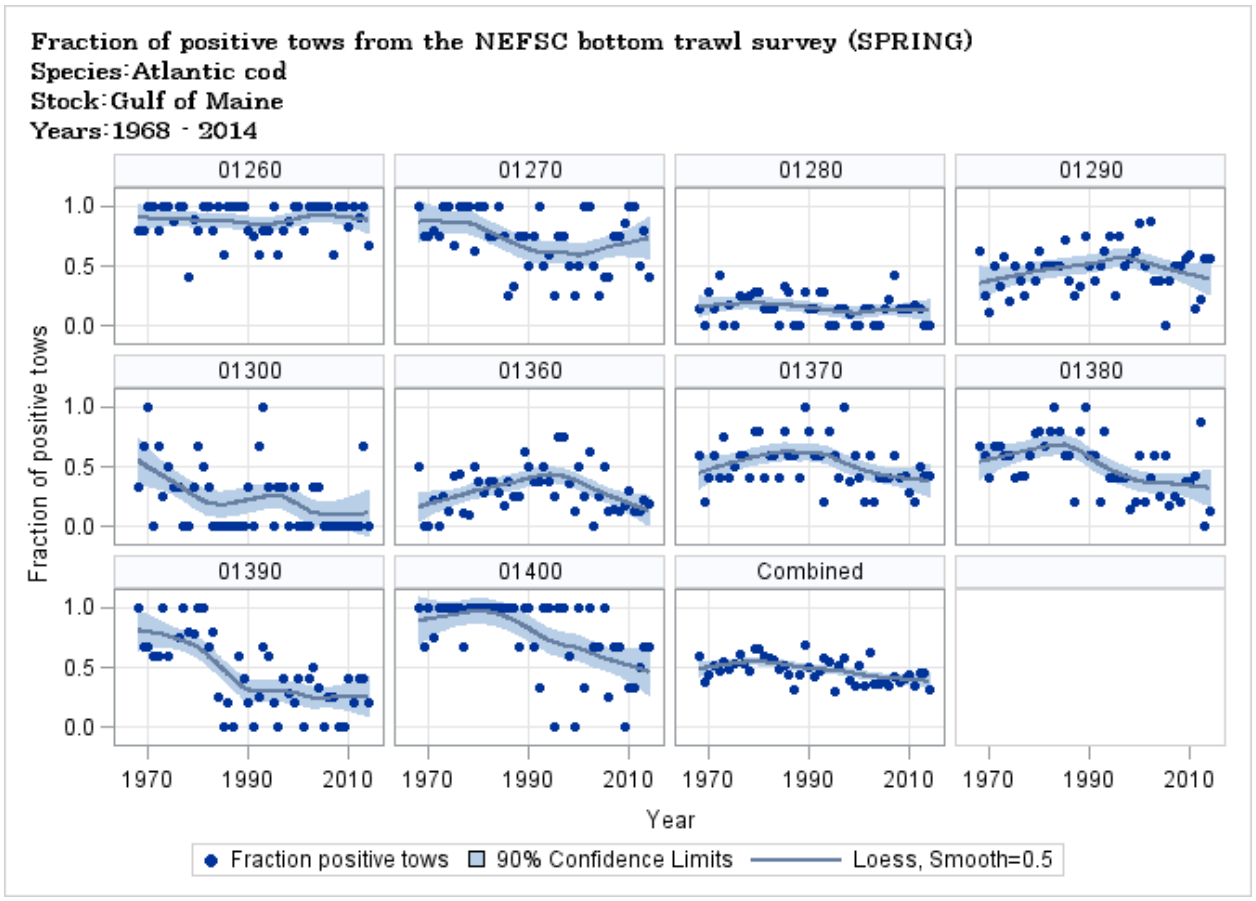

Figure A26. Fraction of Northeast Fisheries Science Center (NEFSC) spring bottom trawl survey tows with positive catches of Gulf of Maine Atlantic cod (*Gadus morhua*) by strata from 1968-2014.

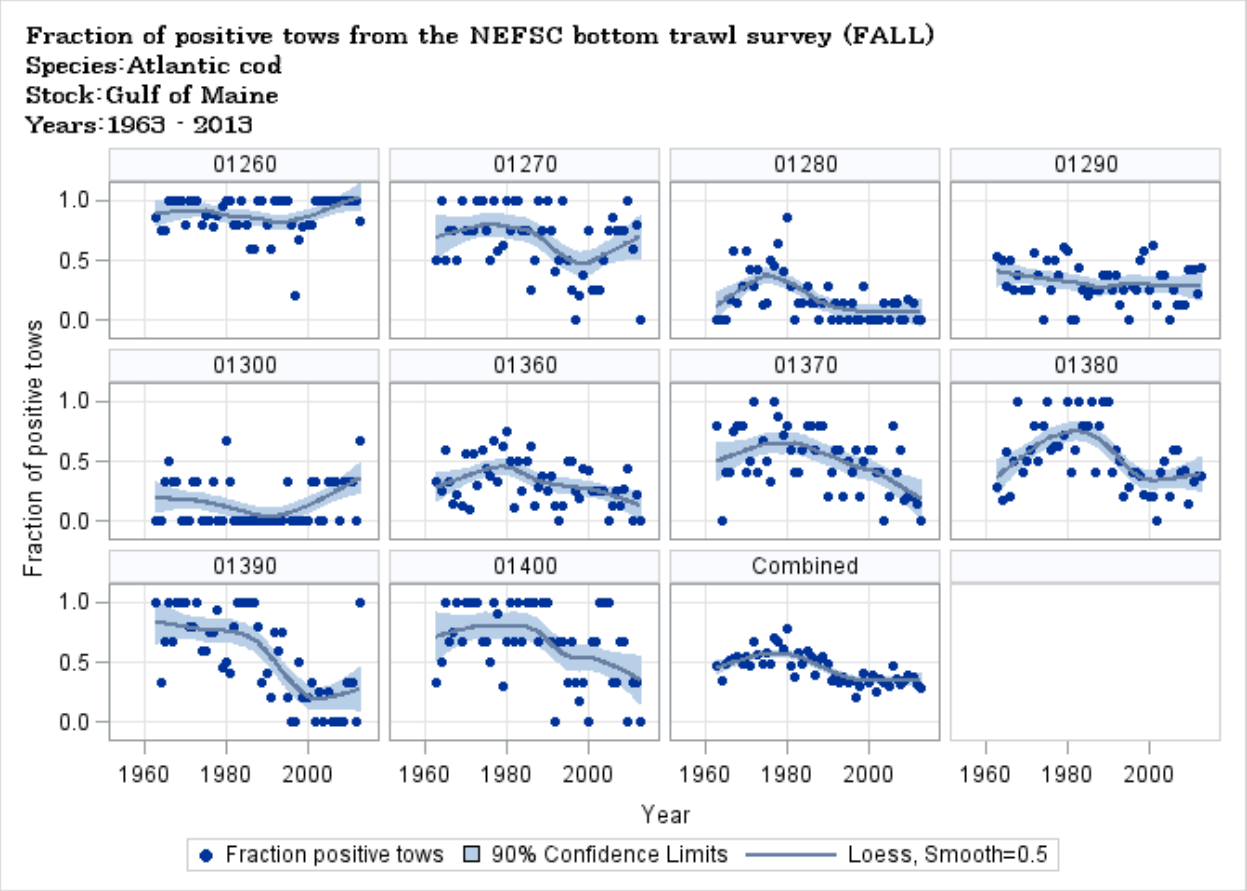

Figure A27. Fraction of Northeast Fisheries Science Center (NEFSC) fall bottom trawl survey tows with positive catches of Gulf of Maine Atlantic cod (*Gadus morhua*) by strata from 1963-2013.

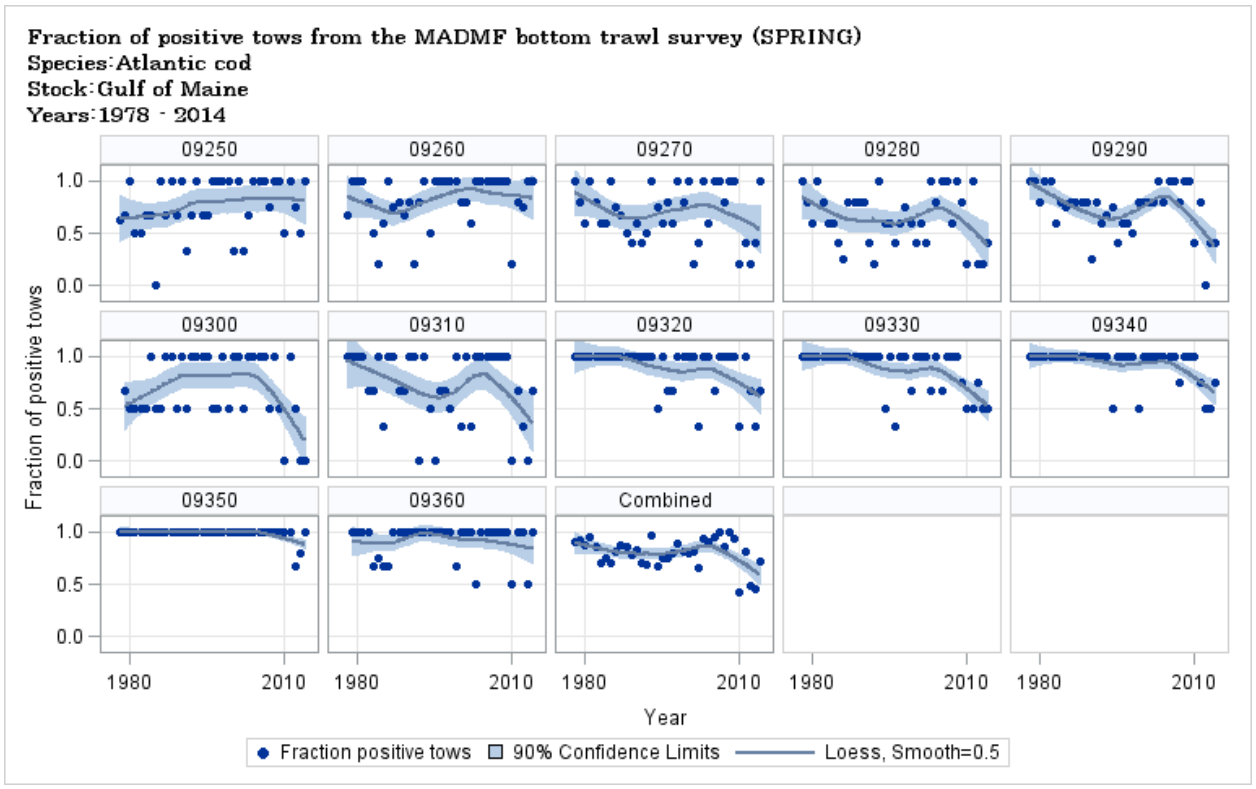

Figure A28. Fraction of Massachusetts Division of Marine Fisheries (MADMF) inshore spring trawl survey tows with positive catches of Gulf of Maine Atlantic cod (*Gadus morhua*) by strata from 1978-2014.

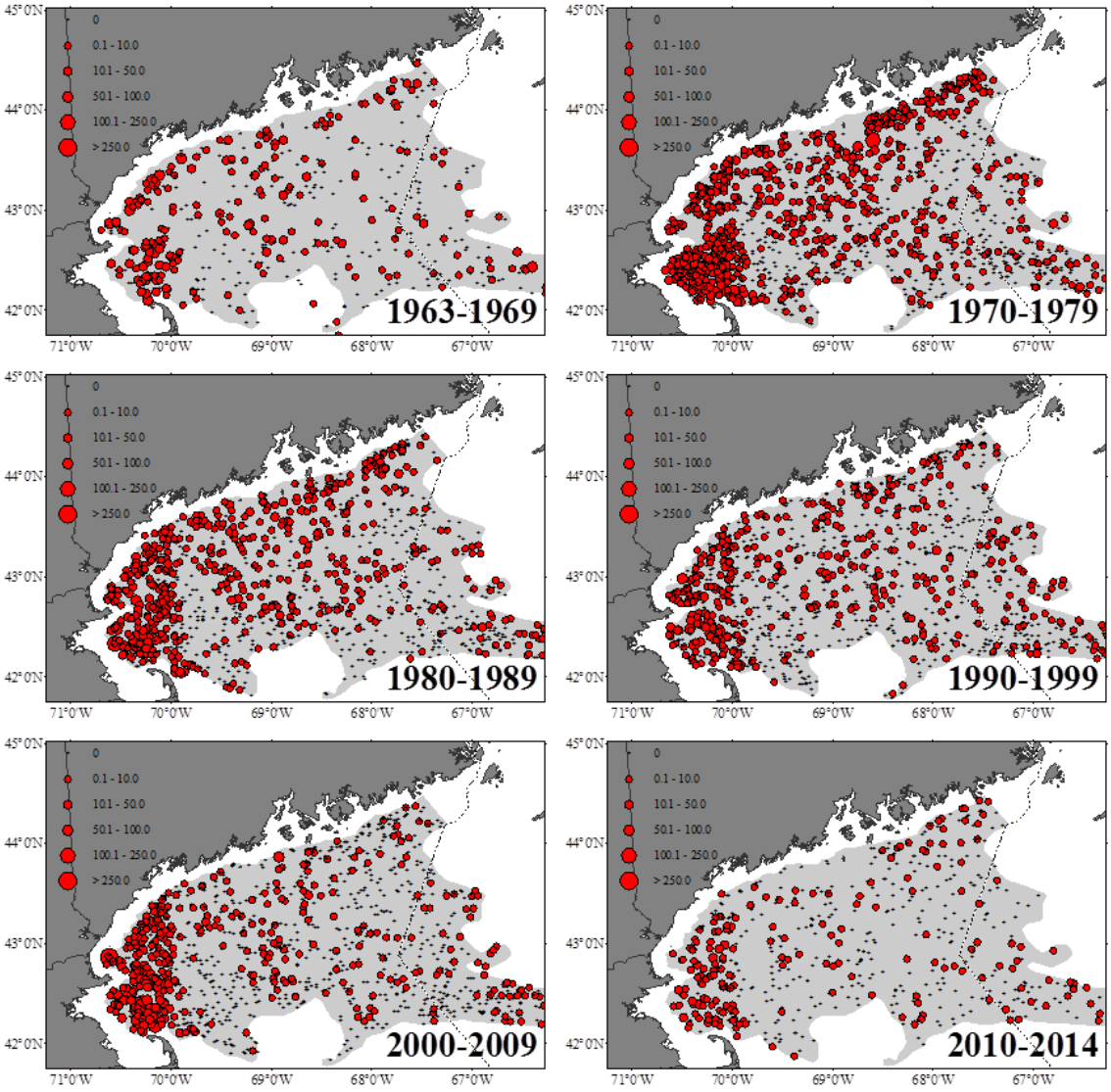

Figure A29. Spatial distribution of Gulf of Maine Atlantic cod (*Gadus morhua*) catches (numbers/tow) from the Northeast Fisheries Science Center spring and fall bottom trawl survey from 1963 – 2014 by decade. *Note that the upper left and lower right hand plots only contain partial decades and that in the upper left hand plot the spring survey did not begin until 1968.*

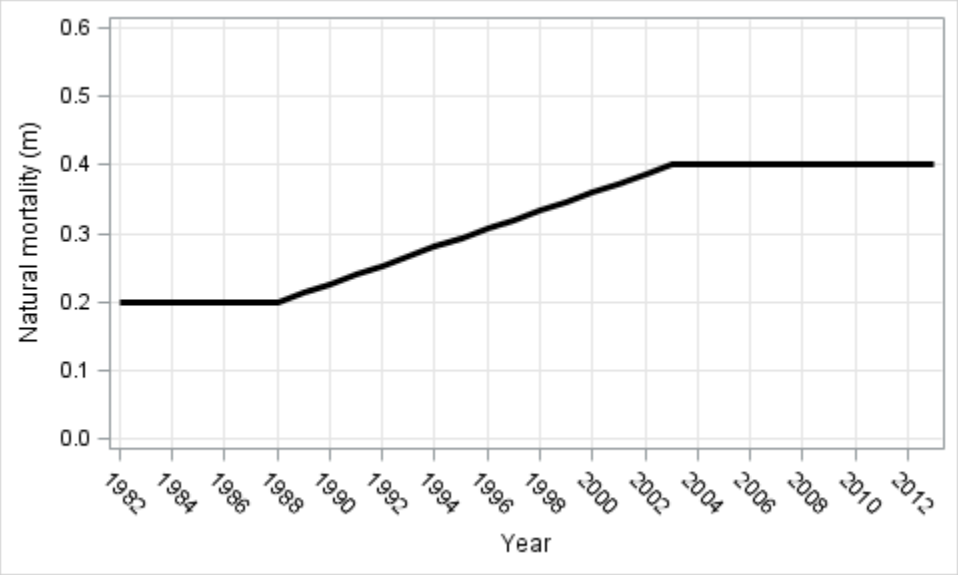

Figure A30. Time series of natural mortality used in the Gulf of Maine Atlantic cod (*Gadus morhua*) natural M-ramp assessment model.

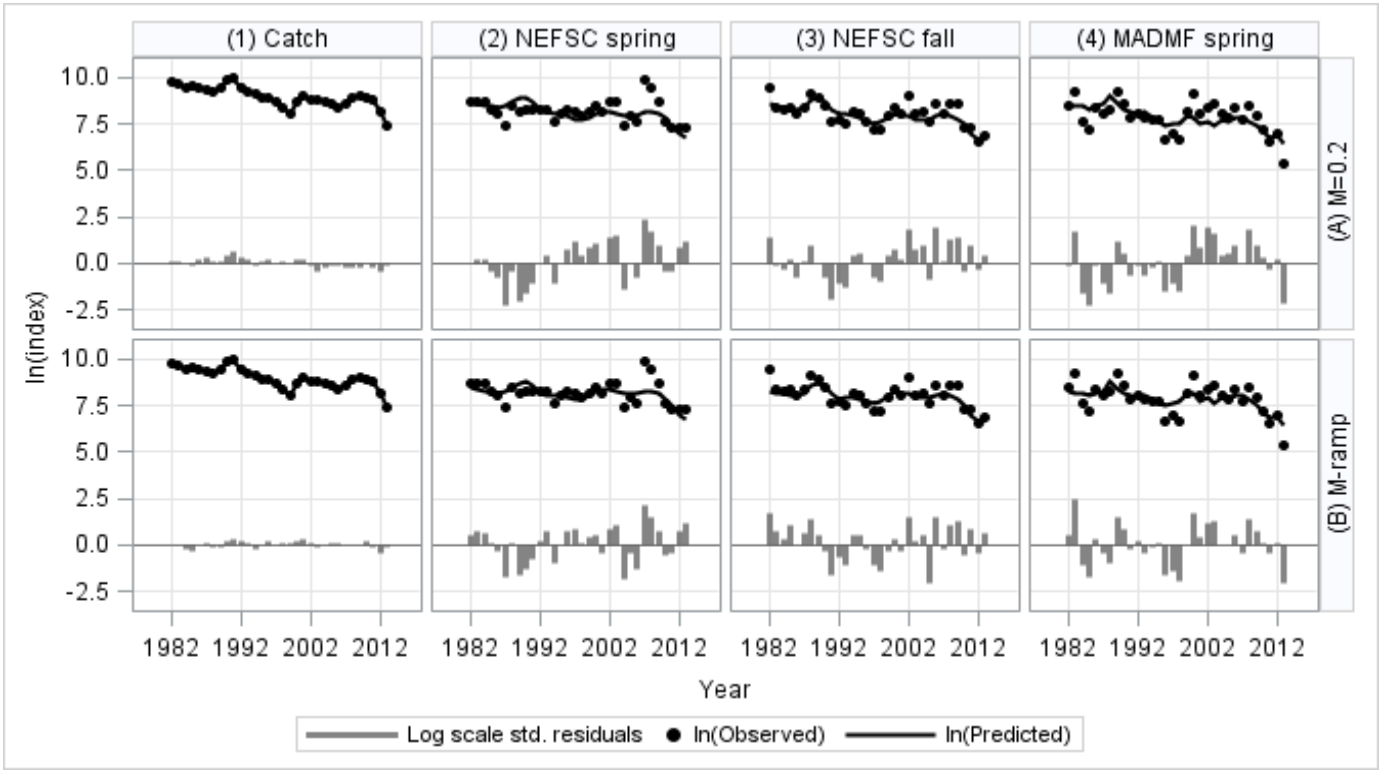

Figure A31. Comparison of model fits to aggregate catch and survey indices and the corresponding standardized residuals from the M=0.2 and M-ramp Gulf of Maine Atlantic cod (*Gadus morhua*) assessment models.

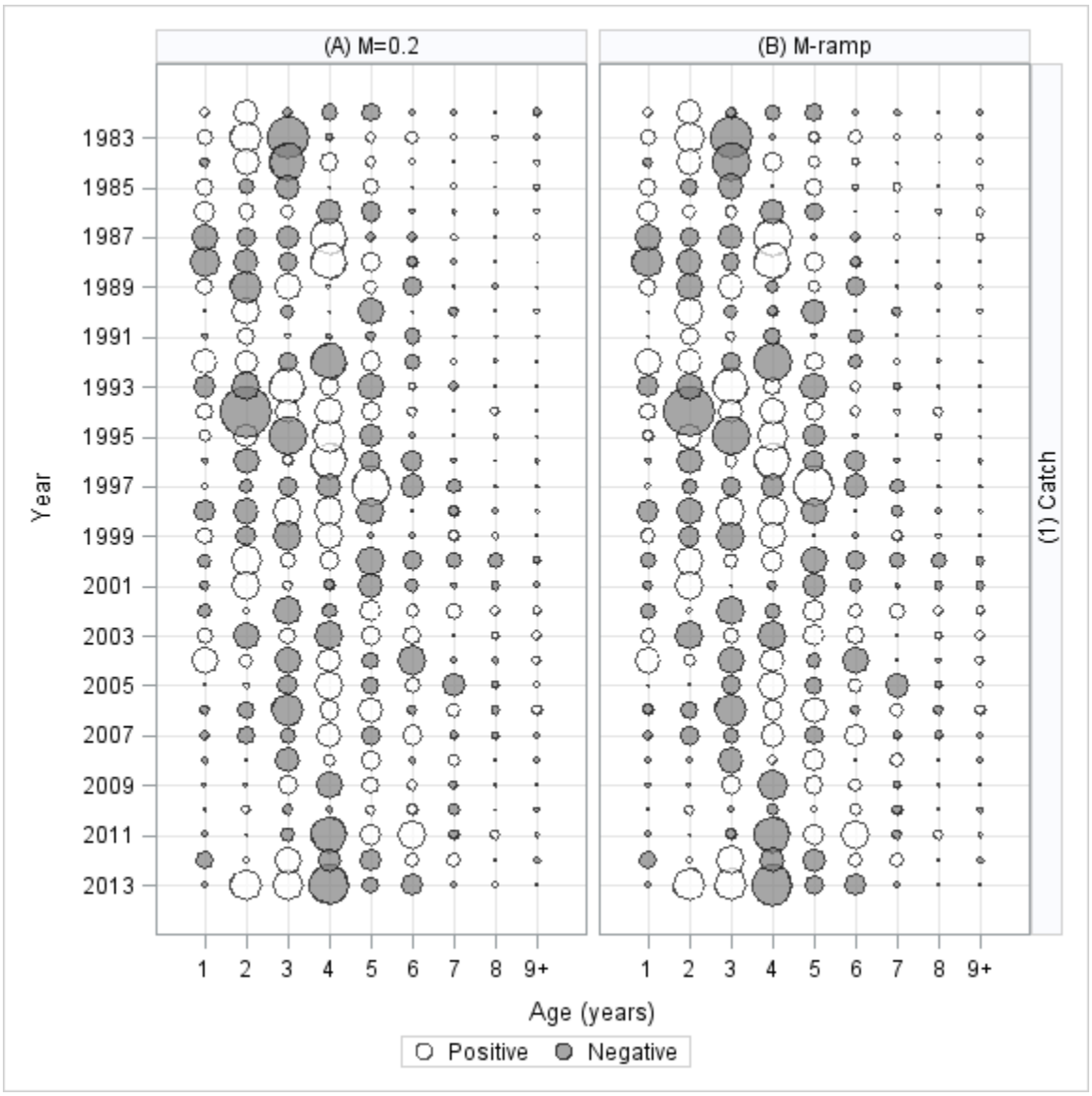

Figure A32. Model residuals of the fits to the Gulf of Maine Atlantic cod (*Gadus morhua*) fishery catch-at-age for the M=0.2 and M-ramp Gulf of Maine Atlantic cod assessment models.

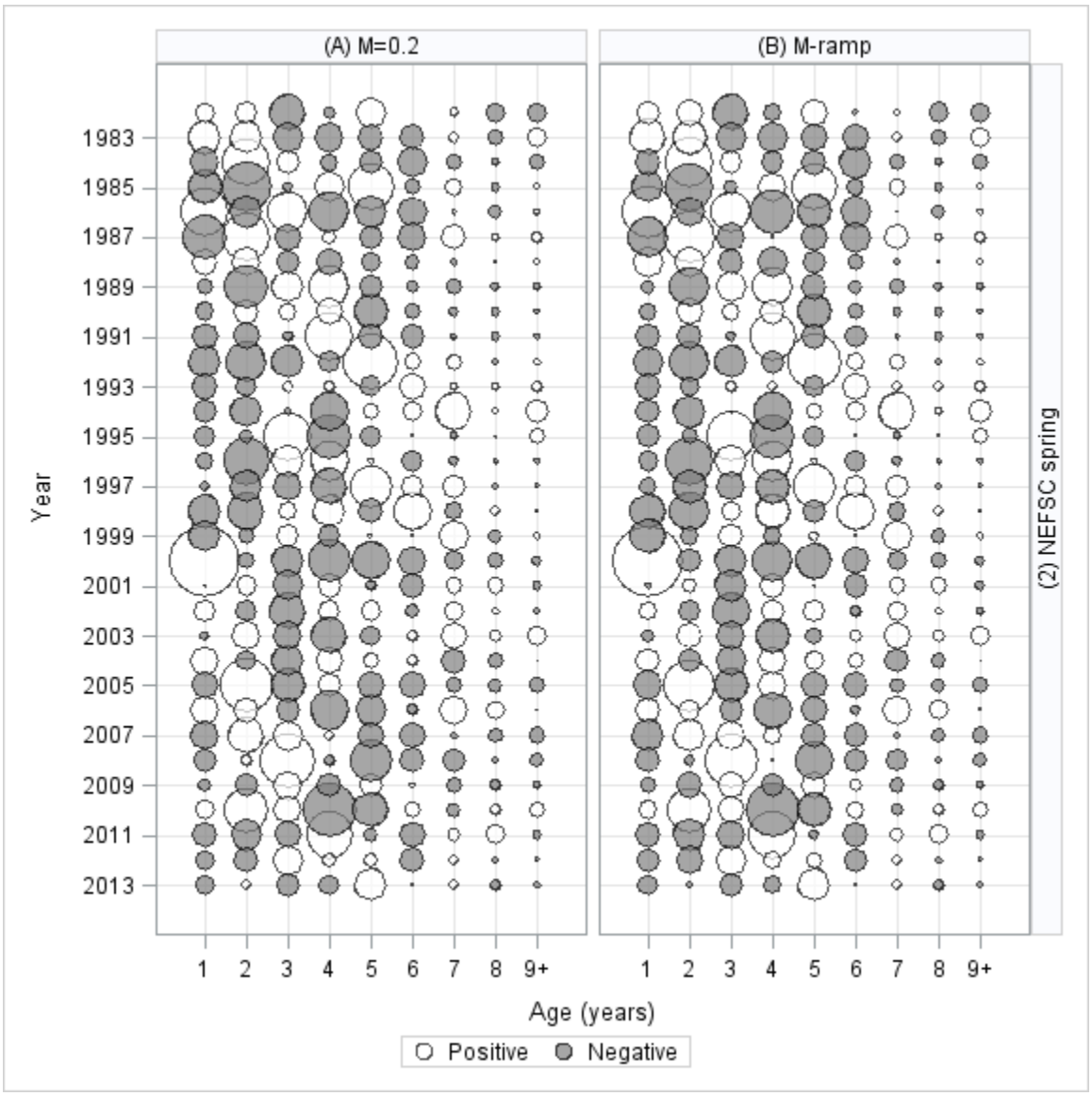

Figure A33. Model residuals of the fits to the NEFSC spring survey Gulf of Maine Atlantic cod (*Gadus morhua*) indices-at-age for the M=0.2 and M-ramp Gulf of Maine Atlantic cod assessment models.

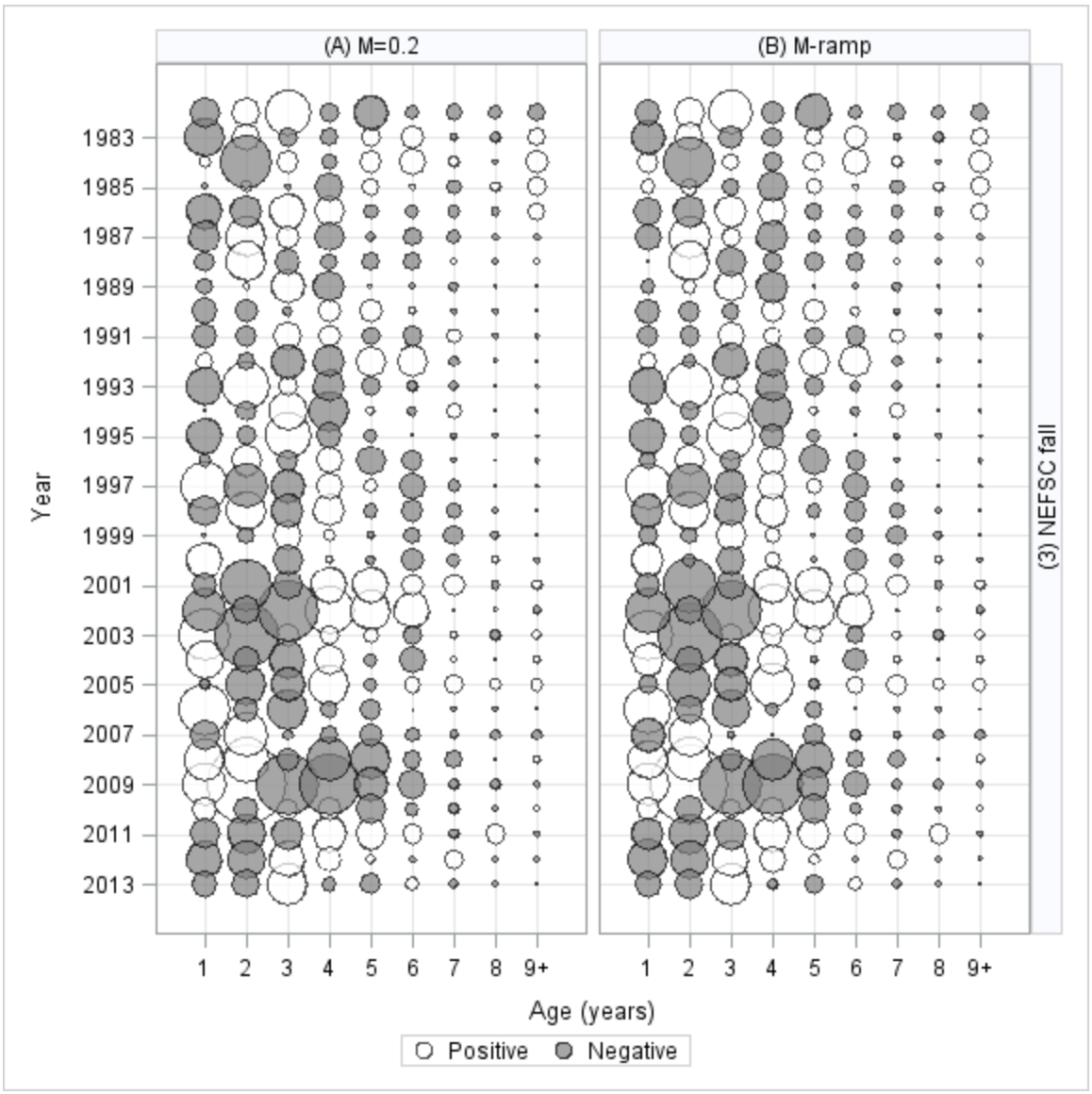

Figure A34. Model residuals of the fits to the NEFSC fall survey Gulf of Maine Atlantic cod (*Gadus morhua*) indices-at-age for the M=0.2 and M-ramp Gulf of Maine Atlantic cod assessment models.

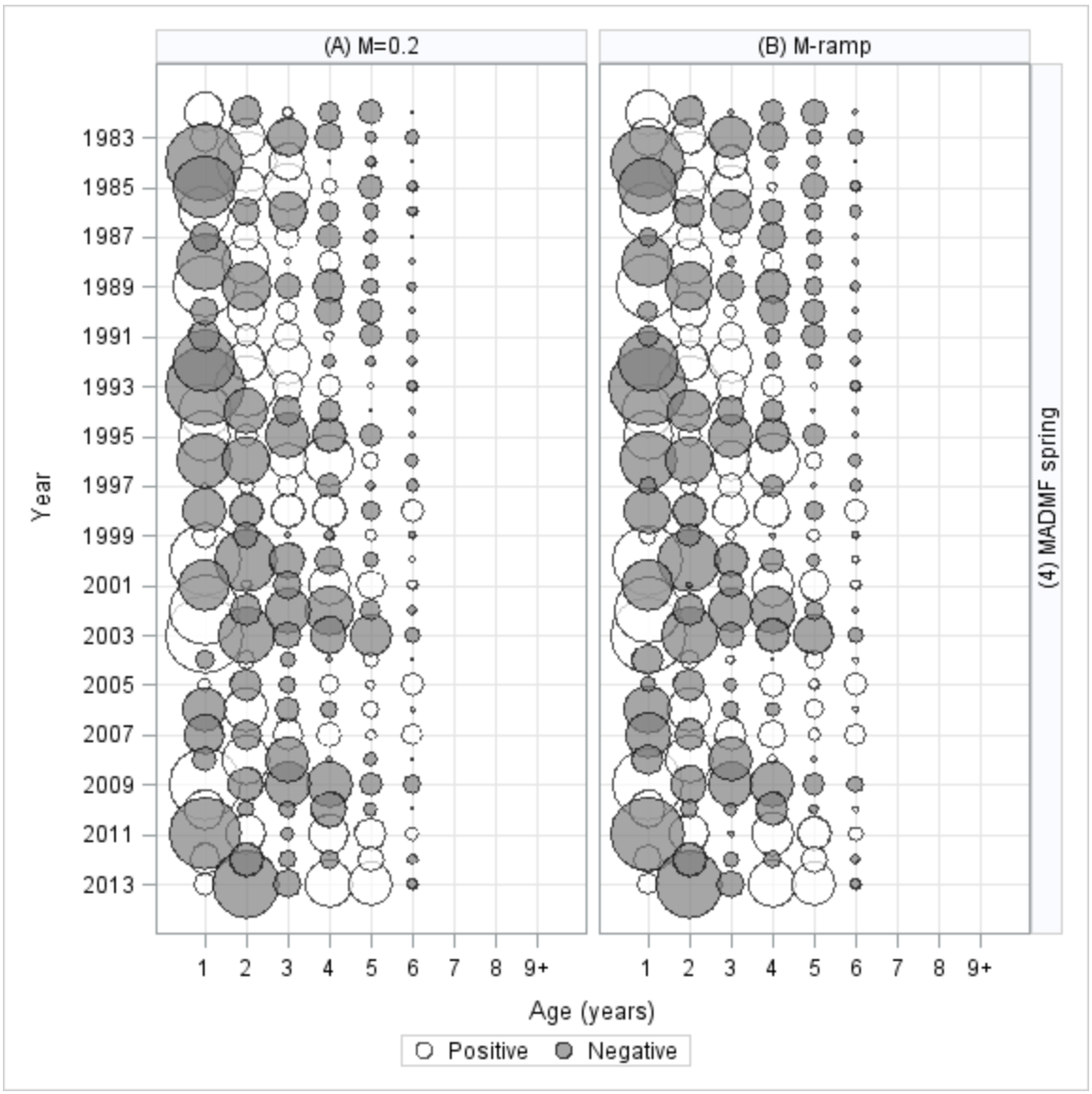

Figure A35. Model residuals of the fits to the MADMF spring survey Gulf of Maine Atlantic cod (*Gadus morhua*) indices-at-age for the M=0.2 and M-ramp Gulf of Maine Atlantic cod assessment models.

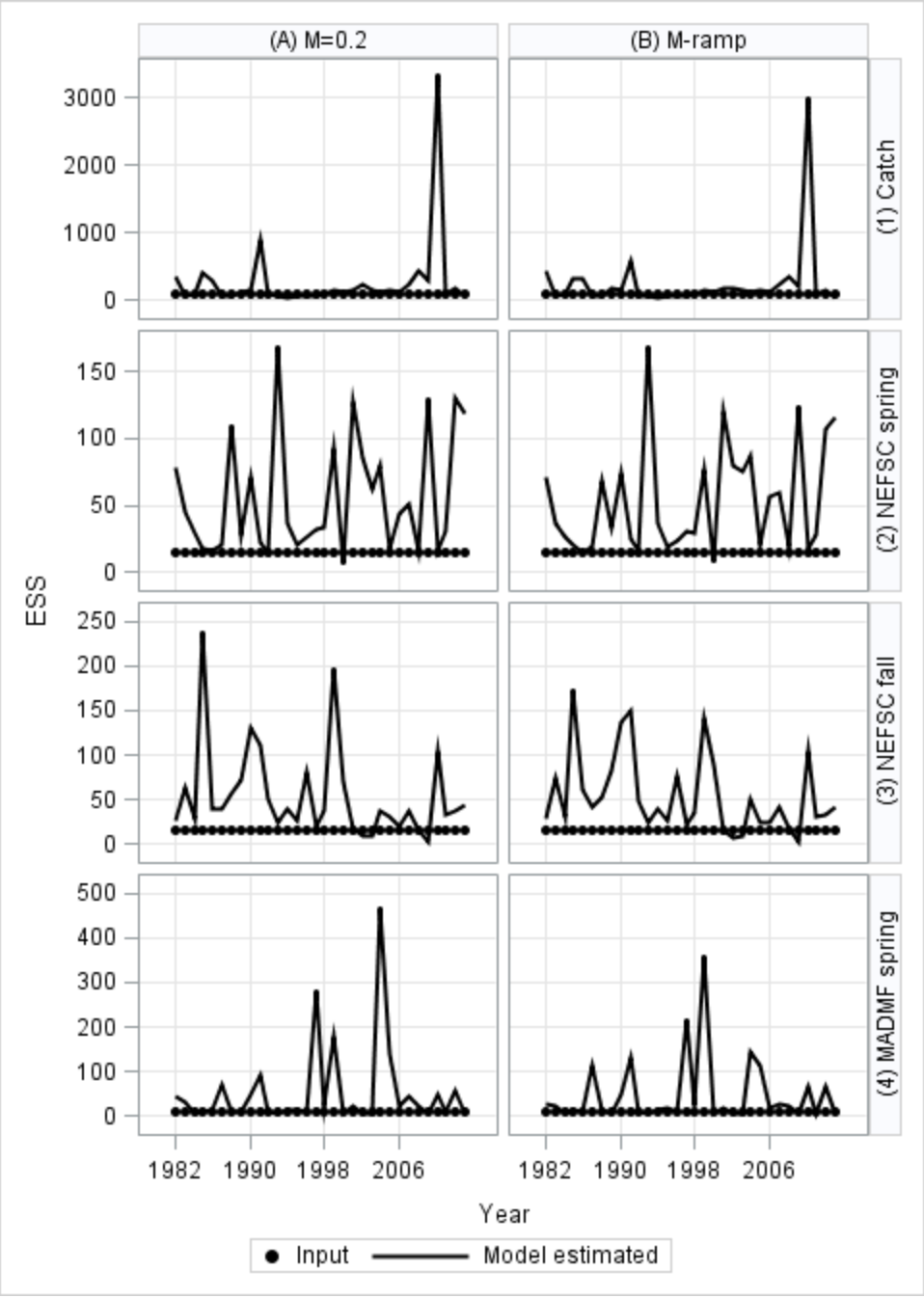

Figure A36. Comparison of the input and model estimated effective sample sizes (ESS) from the Gulf of Maine Atlantic cod (*Gadus morhua*) M=0.2 and M-ramp assessment models. See NEFSC (2013) for a full description of the methods used to determine input ESS.

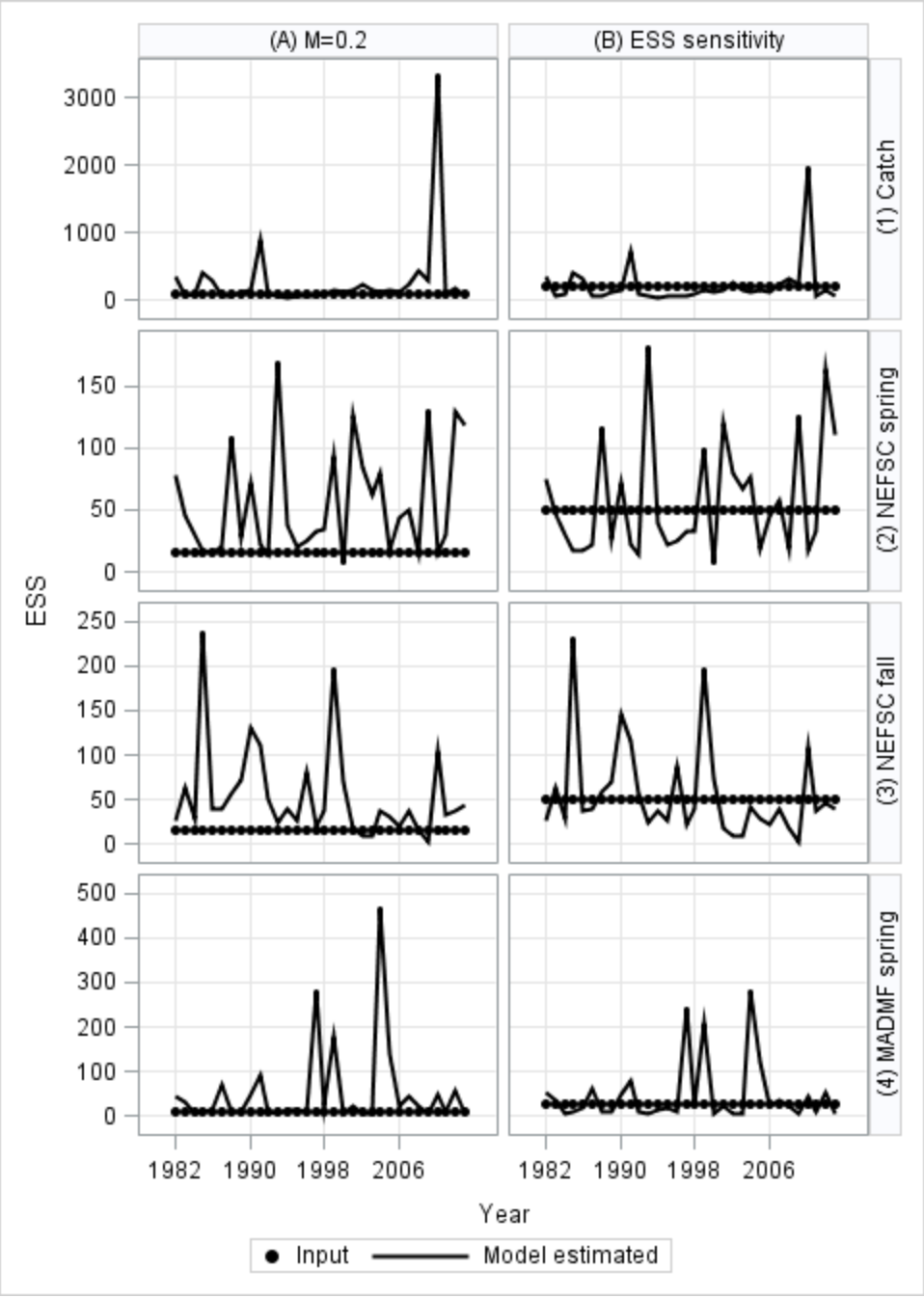

Figure A37. Comparison of the input and model estimated effective sample sizes (ESS) from a sensitivity of the Gulf of Maine Atlantic cod (*Gadus morhua*) M=0.2 model using ad hoc adjustment of ESS (right) compared to the Francis second stage multiplier approached used in the base model (left). See NEFSC (2013) for a full description of the methods used to determine input ESS.

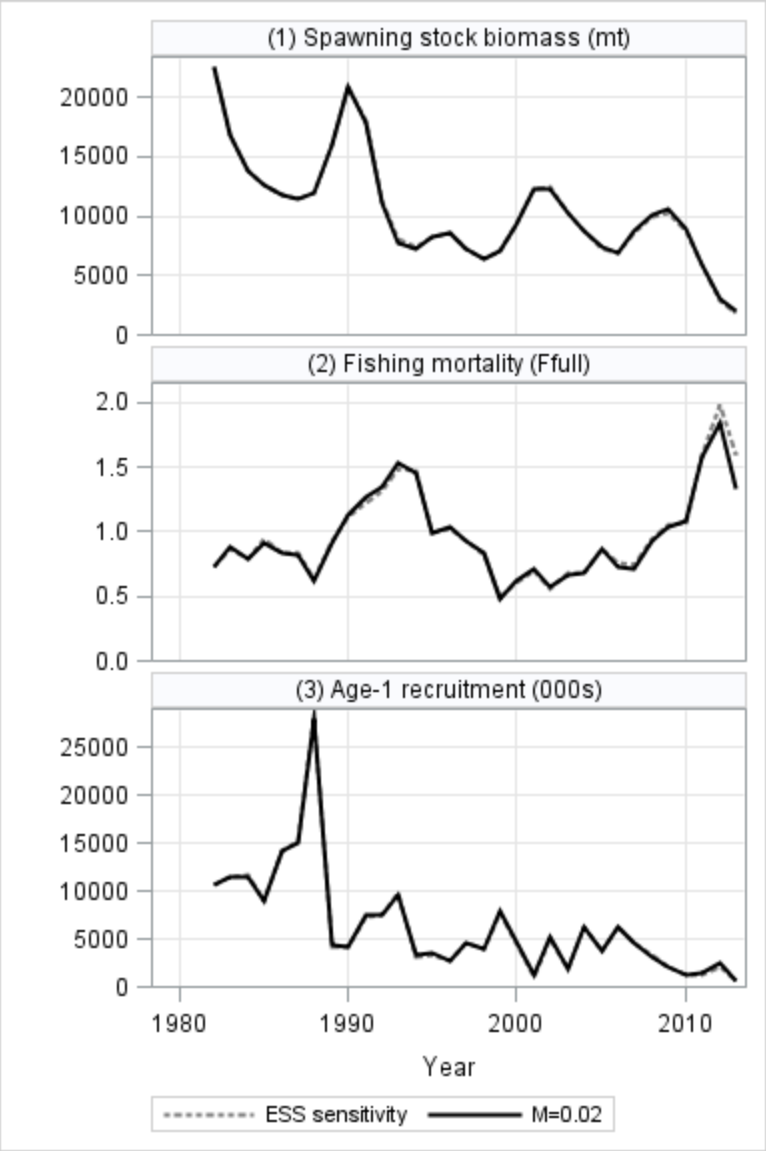

Figure A38. Comparison of the model results from a sensitivity of the Gulf of Maine Atlantic cod (*Gadus morhua*) M=0.2 model using ad hoc adjustment of ESS (right) compared to the Francis second stage multiplier approached used in the base model (left).

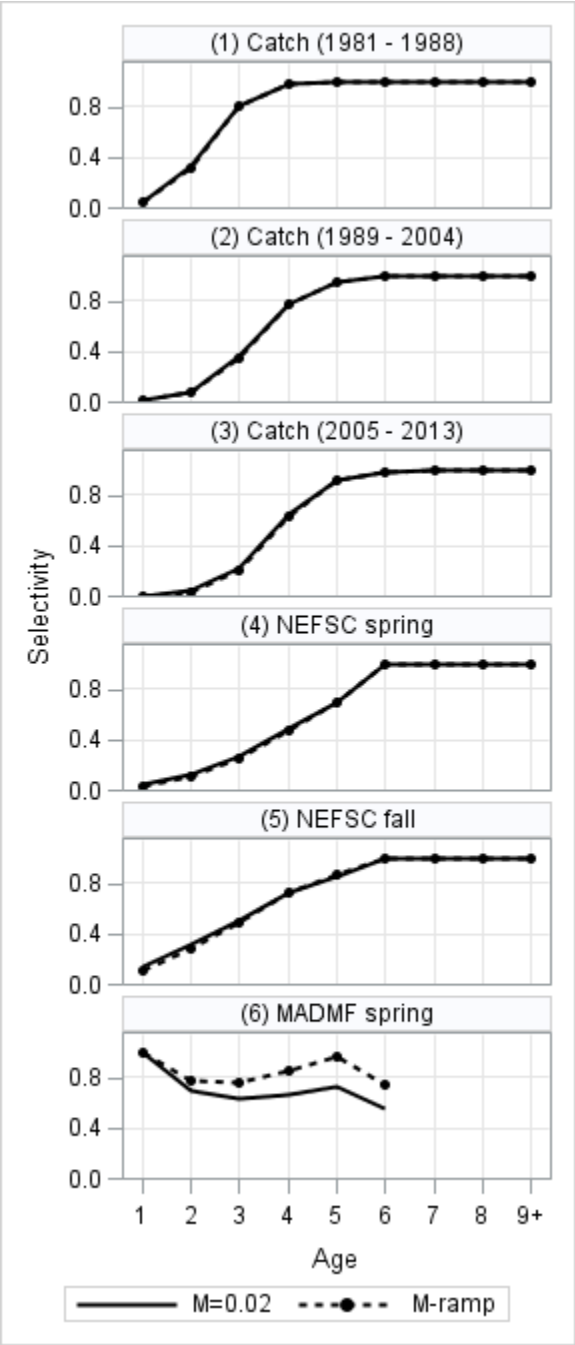

Figure A39. Estimated fishery selectivities for Gulf of Maine Atlantic cod (*Gadus morhua*) from the M=0.2 and M-ramp assessment models.

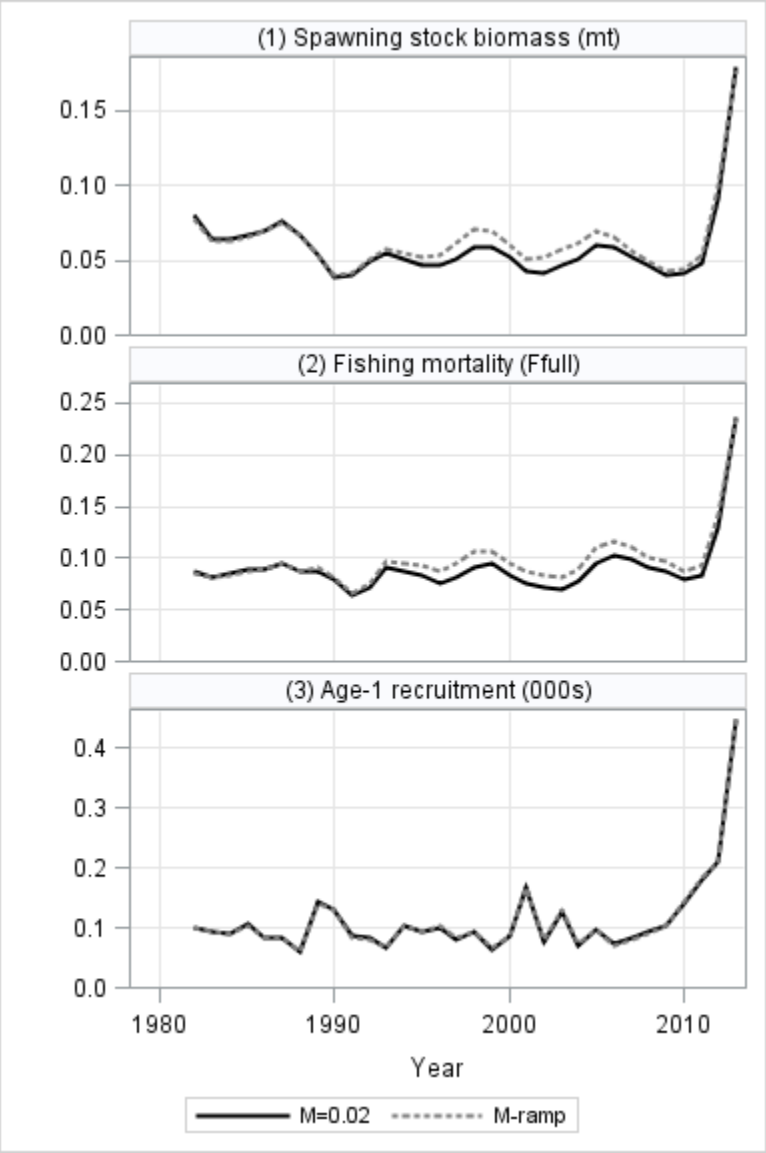

Figure A40. Coefficients of variation (CV) for the M=0.2 and M-ramp assessment model estimates of Gulf of Maine Atlantic cod (*Gadus morhua*) spawning stock biomass (SSB), average fishing mortality and age-1 recruitment.

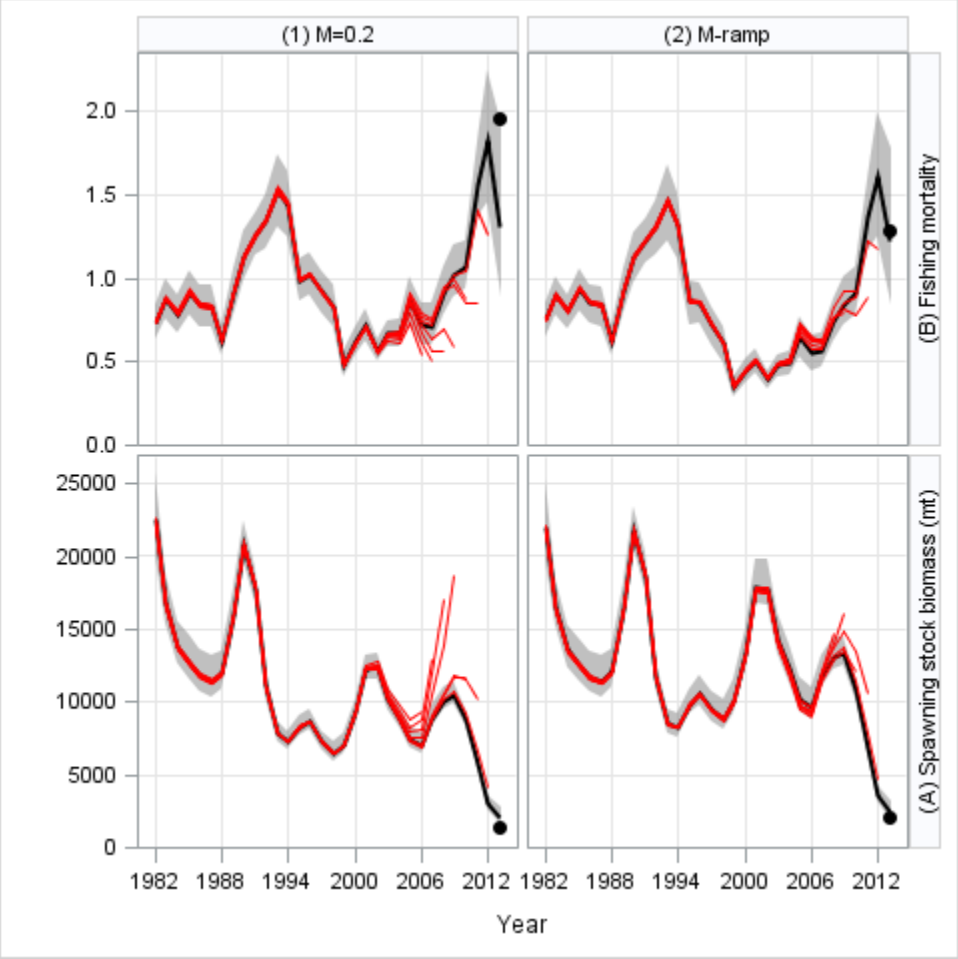

Figure A41. Model retrospective patterns (7-year peel) for sensitivity runs of the Gulf of Maine Atlantic cod (*Gadus morhua*) M=0.2 and M-ramp assessment models. 90% posterior probability intervals of the terminal (2013) model run are indicated by the grey band and the rho adjusted value is indicated by the black circle.

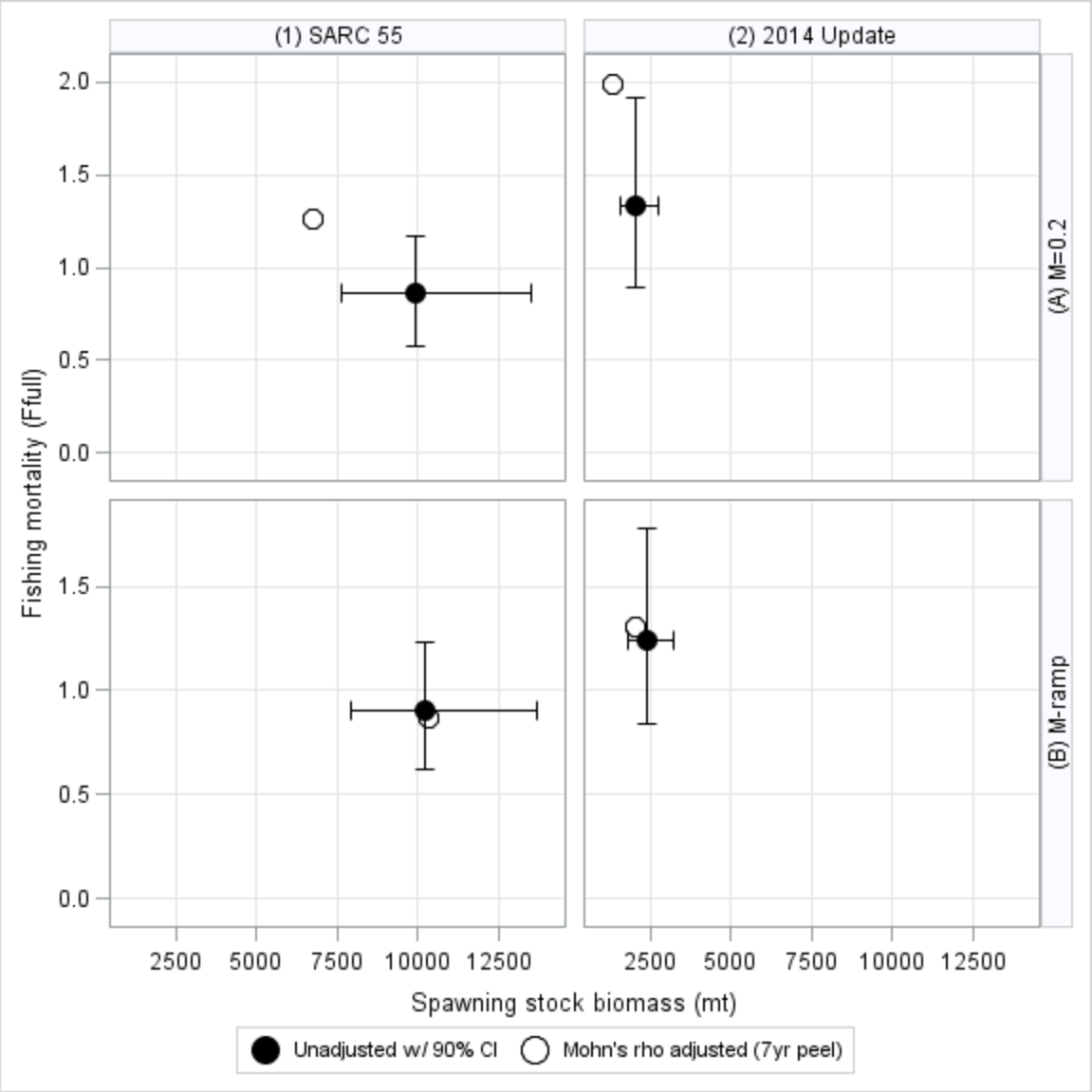

Figure A42. Cross plot of the Gulf of Maine Atlantic cod (*Gadus morhua*) terminal (2011/2013) fully selected fishing mortality and spawning stock biomass for the M=0.2 and M-ramp models from both the SARC 55 (NEFSC 2013) and 2014 Update stock assessments. The error bars indicate the 90% posterior probability intervals on the terminal estimates. The rho adjusted value (7-year peel) is indicated by the open circle.

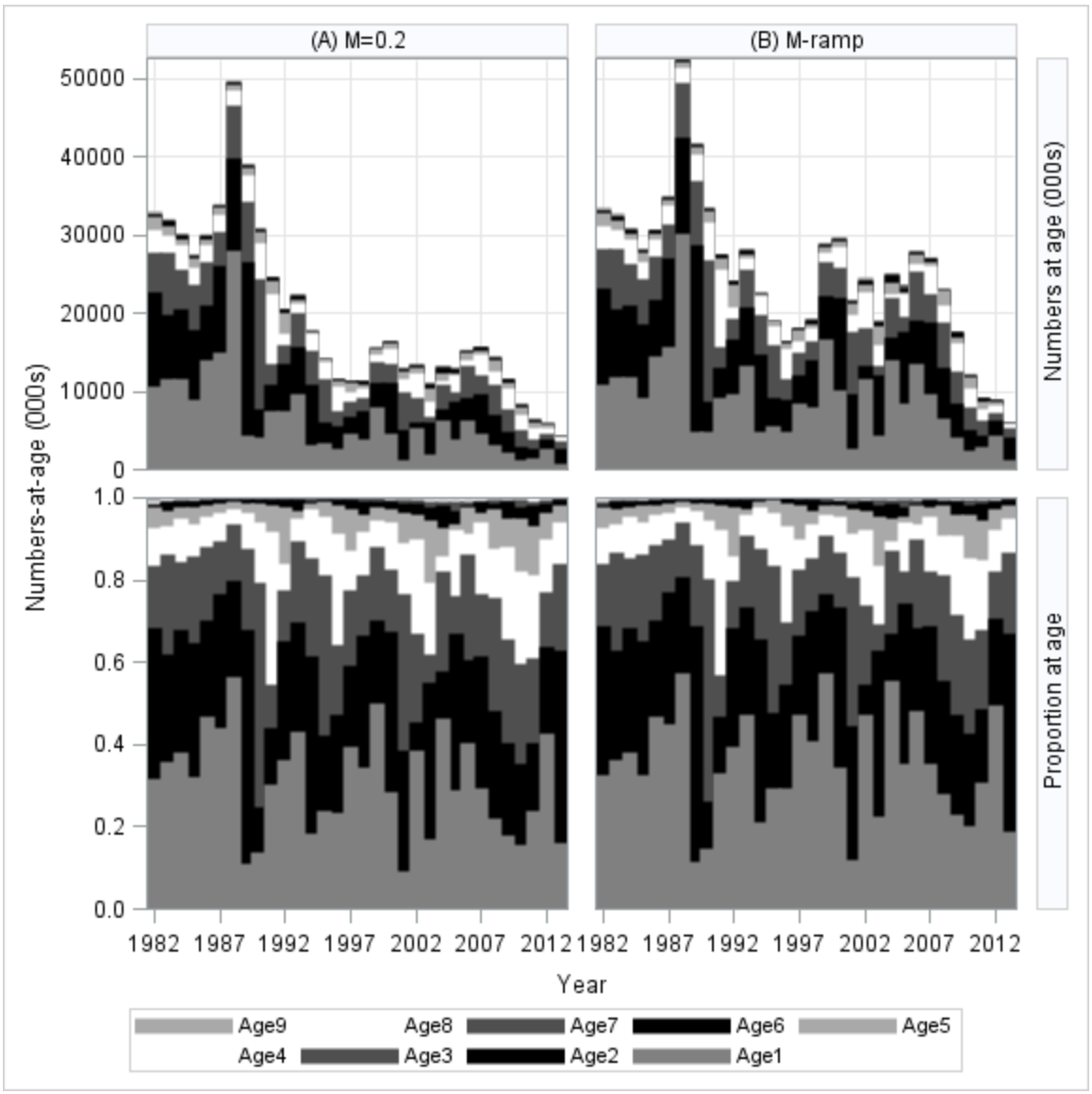

Figure A43. Model estimates of Gulf of Maine Atlantic cod (*Gadus morhua*) numbers-at-age in absolute (top) numbers (000s) and relative (bottom) term for the M=0.2 and M-ramp models.

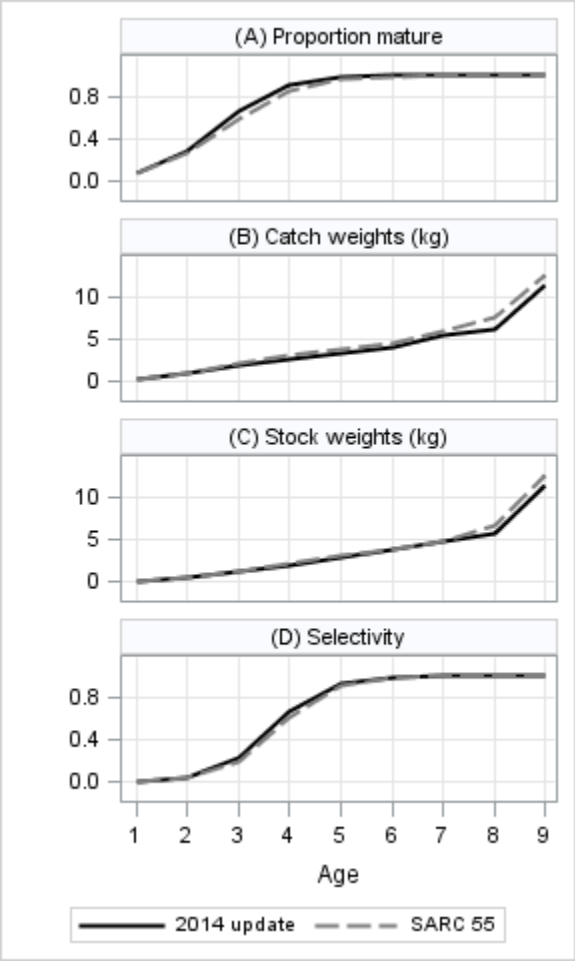

Figure A44. Comparison of the yield-per-recruit/projection inputs used for the SAW/SARC 55 assessment and the 2014 Update of the Gulf of Maine Atlantic cod (*Gadus morhua*) stock assessment.

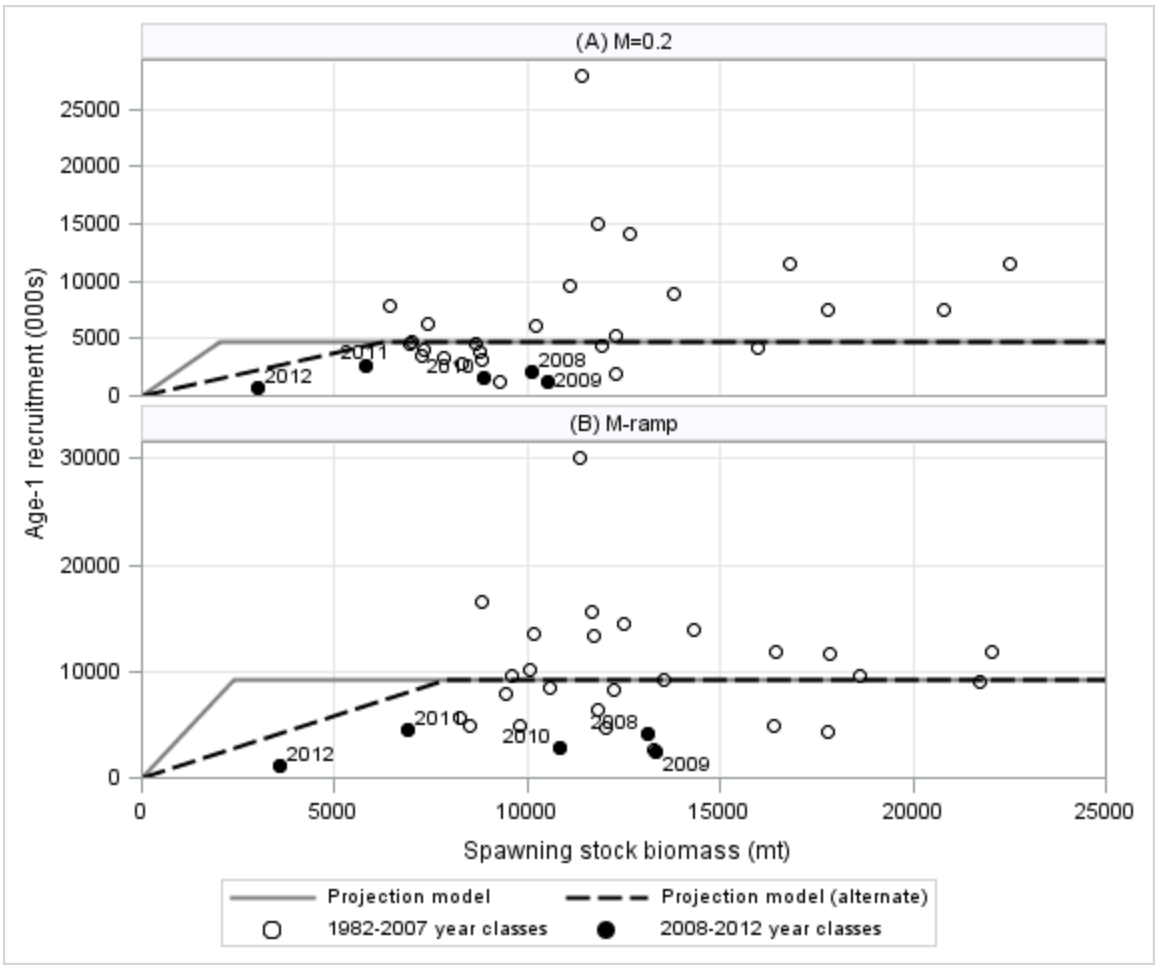

Figure A45. Scatterplot of Gulf of Maine Atlantic cod (*Gadus morhua*) age-1 recruitment and spawning stock biomass as estimated from the M=0.2 and M-ramp models. The projection model used for the base projection model applies the same method as determined at SARC 55 for establishing the SSB hinge value (lowest observed SSB in the time series). The alternate projection model retains the hinge values from SARC 55.

APPENDIX B. ADDITIONAL MATERIAL REQUESTED BY ASSESSMENT PEER REVIEW PANEL

This appendix contains additional information and analyses requested by the Gulf of Maine Atlantic cod (*Gadus morhua*) 2014 Update Peer Review Panel during the August 28-29, 2014 peer review of the of the stock assessment.

Table B1. Summary of Northeast Fisheries Science Center bottom trawl survey gear interactions (e.g., lobster pot, fixed gear) from 2001 through 2014 within offshore strata 26-30, 36-40. Gear interactions resulting in moved, terminated or aborted tows are summarized in the right hand columns. In most of these circumstances the station was relocated to an alternate location within 1.5 nm of the original station location. *Note that fall 2014 data are not yet available.*

Season	Year	Total attempted tows	Interactions	Proportion of tows with interaction	Impacts		
					Moved	Terminated	Aborted
Spring	2001	56	2	0.04	1	0	0
	2002	60	5	0.08	1	0	0
	2003	55	4	0.07	0	1	1
	2004	51	0	0.00	1	2	1
	2005	51	2	0.04	0	1	0
	2006	60	2	0.03	0	1	0
	2007	53	5	0.09	1	0	0
	2008	52	2	0.04	0	0	0
	2009	78	3	0.04	1	0	0
	2010	68	2	0.03	0	1	0
	2011	58	2	0.03	0	0	0
	2012	79	3	0.04	0	0	0
	2013	72	0	0.00	0	0	0
	2014	64	0	0.00	0	0	0
Fall	2001	54	1	0.02	0	1	0
	2002	52	2	0.04	1	1	0
	2003	55	0	0.00	0	1	0
	2004	51	1	0.02	0	1	0
	2005	51	1	0.02	0	0	0
	2006	59	1	0.02	0	1	0
	2007	53	1	0.02	0	0	0
	2008	75	2	0.03	2	0	0
	2009	57	1	0.02	0	0	0
	2010	56	3	0.05	0	0	0
	2011	53	1	0.02	0	0	0
	2012	65	0	0.00	0	0	0
	2013	63	0	0.00	0	0	0

Table B2. Proportion of Massachusetts Division of Marine Fisheries spring inshore trawl survey tows aborted in inshore strata 25-36 from 2007 through 2014. Tows could have been aborted for several reasons including problems with the survey gear (e.g., crossed doors), large catches of dogfish, encounters with hard bottom, gear conflicts (e.g., lobster pots), etc. In most situations when a tow was aborted the station was relocated to an alternate location within 1.5 nm of the original station location.

Year	Total good stations	Aborted tows (re-towed)	Proportion aborted
2007	47	5	0.11
2008	46	3	0.07
2009	45	12	0.27
2010	47	3	0.06
2011	46	2	0.04
2012	44	4	0.09
2013	46	1	0.02
2014	47	3	0.06

Table B3. Comparison of the Gulf of Maine Atlantic cod (*Gadus morhua*) yield per recruit (YPR), spawning stock biomass per recruit (SSB/R), average and median age-1 recruitment associated with reference points under both the M=0.2 and M-ramp models for both the SARC 55 and the 2014 Update assessments. All reference points are based on an $F_{MSY\text{-}proxy}$ of $F_{40\%}$. *Note that for SARC 55 the M-ramp reference points assumed M=0.2, during the review of the 2014 Update reference points for the M-ramp model were explored assuming M=0.4, though these were not accepted by the peer review panel.*

Assessment	Model	YPR	SSB/R	Average Age-1 recruitment (000s)	Median age-1 recruitment (000s)
SARC 55	M=0.2	1.40	8.15	5,254	6,900
	M-ramp (M=0.2)	1.40	8.15	9,446	10,000
2014 Update	M=0.2	1.24	7.55	4,665	6,400
	M-ramp (M=0.2)	1.24	7.55	9,173	9,300
	M-ramp (M=0.4)	0.51	1.55	9,173	9,300

Table B4. Biological reference points and stock status for Gulf of Maine Atlantic cod (*Gadus morhua*) based on SARC 55 benchmark assessment (NEFSC 2013) and the revised 2014 Update assessment. Intervals shown are the 5th and 95th percentiles. This is an update of Table 2 with two additional sets of reference points included for the M-ramp model, though these were not accepted by the peer review panel. The first new set of reference points is based on an $F_{MSY\text{-}proxy}$ of 0.18 but an assumption of natural mortality of M=0.4. The second set of new reference points revises the $F_{MSY\text{-}proxy}$ to 0.45 (F40% associated with yield per recruit analysis assuming M=0.4) and an assumption of natural mortality of M=0.4.

Assessment	Proxy reference points	M=0.2	M-ramp	M-ramp (M=0.4)	M-ramp (M=0.4) w/revised $F_{40\%}$
SARC 55	$F_{full,\,2011}$	0.86 (0.58 - 1.17)	0.90 (0.62 - 1.23)		
	F_{MSY}	0.18	0.18		
	$F_{full,\,2011}/F_{MSY}$	4.78	5.00		
	Overfishing	Yes	Yes		
	SSB_{2011} (mt)	9,903 (7,644 - 13,503)	10,221 (7,943 - 13,676)		
	SSB_{MSY} (mt)	54,743 (40,207 - 73,354)	80,200 (64,081 - 99,972)		
	SSB_{2011}/SSB_{MSY}	0.18	0.13		
	Overfished	Yes	Yes		
	MSY (mt)	9,399 (6,806 - 13,153)	13,786 (10,900 - 17,329)		
	Median age1 recruitment (000s)	5,254 (2,206 - 14,727)	9,446 (4,480 - 16,321)		
2014 update	$F_{full,\,2013}$	1.33 (0.89 - 1.92)	1.24 (0.84 - 1.78)	1.24 (0.84 - 1.78)	1.24 (0.84 - 1.78)
	F_{MSY}	0.18	0.18	0.18	0.45
	$F_{full,\,2013}/F_{MSY}$	7.39	6.89	6.89	2.76
	Overfishing	Yes	Yes	Yes	Yes
	SSB_{2013} (mt)	2,063 (1,561 - 2,774)	2,432 (1,819 - 3,230)	2,432 (1,819 - 3,230)	2,432 (1,819 - 3,230)
	SSB_{MSY} (mt)	47,184 (32,903 - 67,045)	69,621 (53,349 - 89,302)	21,651 (15,768 - 28,887)	14,002 (9,551 - 19,605)
	SSB_{2013}/SSB_{MSY}	0.04	0.03	0.11	0.17
	Overfished	Yes	Yes	Yes	Yes
	MSY (mt)	7,753 (5,355 - 11,162)	11,388 (8,624 - 14,750)	3,219 (2,320 - 4,326)	4,685 (3,146 - 6,621)
	Median age1 recruitment (000s)	4,665 (1,414 - 14,649)	9,173 (2,682 - 16,262)	9,173 (2,682 - 16,262)	9,173 (2,682 - 16,262)

Table B5. Update of Table 1.37 (alternate projection scenario with revised recruitment) which includes two additional short-term projections for the Gulf of Maine Atlantic cod (*Gadus morhua*) M-ramp model. The first new scenario is based on an assumption of M=0.4 in the short-term projections with an $F_{MSY\text{-}proxy}$ of 0.18 ($F_{40\%}$ associated with yield per recruit analysis assuming M=0.2) but rebuilding to a SSB_{MSY} level of 21,651 mt. The second new scenario is based on an assumption of M=0.4 in the short-term projections with an $F_{MSY\text{-}proxy}$ of 0.45 ($F_{40\%}$ associated with yield per recruit analysis assuming M=0.4) but rebuilding to a SSB_{MSY} level of 14,002 mt. The peer review panel did not accept the projections associated with the M=0.2 retrospective adjustment or either of the two new M-ramp projections described above.

Harvest strategy	Year	Input	M=0.2 model						M-ramp model											
			No retro adjustment			Retrospective adjustment			M=0.2			M=0.4			M=0.4 (F_{MSY} = 0.18, SSB_{MSY} = 21.7 kmt)			M=0.4 (F_{MSY} = 0.45, SSB_{MSY} = 14.0 kmt)		
			Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}
F_{MSY}	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24						
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91						
	2015	Projection	506	3,297	0.18	252	1,703	0.18	584	3,972	0.18	421	3,008	0.18						
	2016	Projection	709	4,564	0.18	380	2,504	0.18	868	5,929	0.18	519	3,744	0.18						
	2017	Projection	941	6,191	0.18	530	3,501	0.18	1,239	8,497	0.18	622	4,550	0.18						
75% F_{MSY}	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91	1,550	2,813	0.91	1,550	2,813	0.91
	2015	Projection	399	3,318	0.14	199	1,713	0.14	460	3,997	0.14	332	3,027	0.14	332	3,027	0.14	756	2,935	0.34
	2016	Projection	573	4,693	0.14	306	2,570	0.14	701	6,083	0.14	419	3,837	0.14	419	3,837	0.14	852	3,403	0.34
	2017	Projection	776	6,469	0.14	434	3,645	0.14	1,016	8,828	0.14	509	4,721	0.14	509	4,721	0.14	970	3,967	0.34
$F_{rebuild}$	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24	1,715	2,432	1.24	1,715	2,432	1.24
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91	1,550	2,813	0.91	1,550	2,813	0.91
	2015	Projection	176	3,361	0.06	***0***	***1,749***	***0.00***	203	4,047	0.06	***0***	***3,093***	***0.00***	74	3,079	0.03	530	2,986	0.23
	2016	Projection	266	4,968	0.06	***0***	***2,818***	***0.00***	324	6,401	0.06	***0***	***4,190***	***0.00***	99	4,112	0.03	634	3,632	0.23
	2017	Projection	374	7,074	0.06	***0***	***4,236***	***0.00***	485	9,569	0.06	***0***	***5,414***	***0.00***	126	5,253	0.03	747	4,352	0.23
$F_{no\ action}$	2013	Model result	1,715	2,063	1.33	1,715	1,348	1.99	1,715	2,432	1.24	1,715	2,432	1.24						
	2014	Assumed catch	1,550	2,671	0.86	1,550	1,588	1.56	1,550	2,990	0.81	1,550	2,813	0.91						
	2015	Projection	1,550	3,057	0.64	1,550	1,356	1.61	1,550	3,756	0.54	1,550	2,736	0.80						

Table B6. Number of feasible Gulf of Maine Atlantic cod (*Gadus morhua*) projection simulations from the short-term projections summarized in Table 2.5. A total of 10,000 projection simulations were conducted per projection run; caution should be used in interpreting projections where the number of feasible runs is less than 10,000.

Projection	Harvest strategy	M=0.2 model		M-ramp model			
		Base	Retro	M=0.2	M=0.4	M=0.4 (F_{MSY} = 0.18, SSB_{MSY} = 21.7 kmt	M=0.4 (F_{MSY} = 0.45, SSB_{MSY} = 14.0 kmt)
Standard	F_{MSY}	10,000	9,950	10,000	10,000		
	75% F_{MSY}	10,000	9,950	10,000	10,000		
	$F_{rebuild}$	10,000	9,950	10,000	10,000		
	$F_{no\ action}$	10,000	9,356	10,000	10,000		
Revised recruitment	F_{MSY}	10,000	9,950	10,000	10,000		
	75% F_{MSY}	10,000	9,950	10,000	10,000	10,000	10,000
	$F_{rebuild}$	10,000	9,950	10,000	10,000	10,000	10,000
	$F_{no\ action}$	9,531	4,110	9,992	6,956		

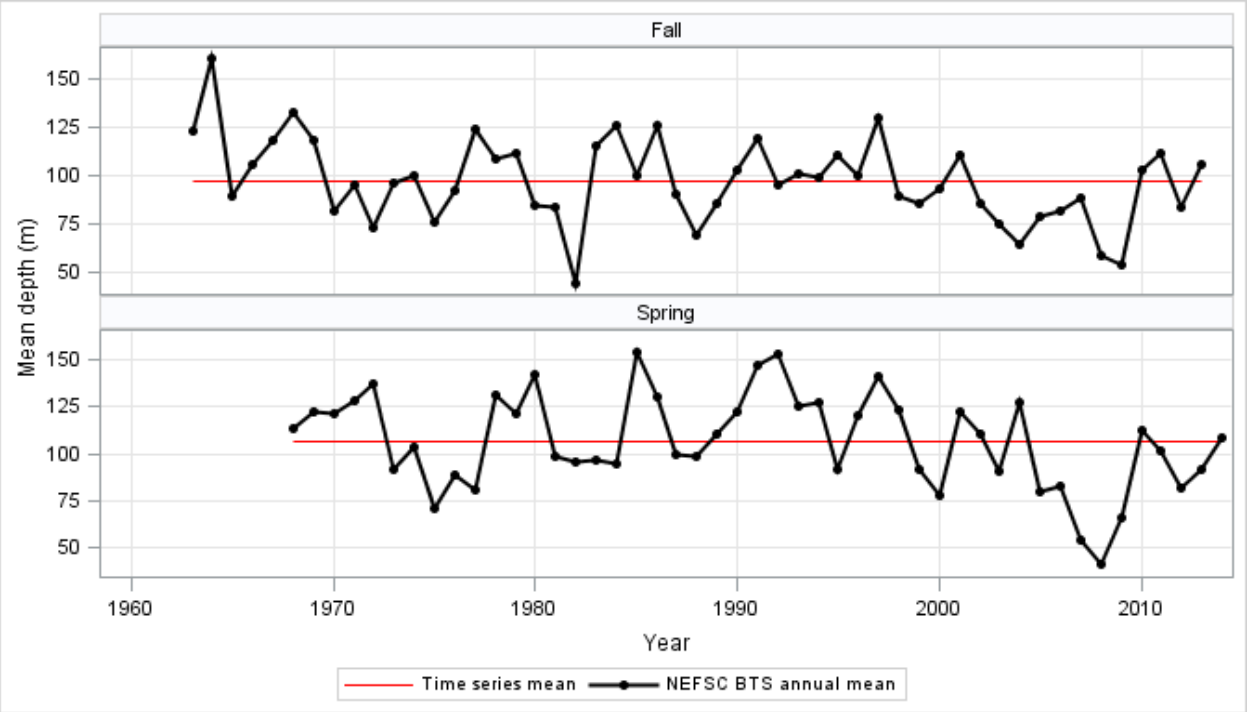

Figure B1. Catch-weighted mean depth of capture of Gulf of Maine Atlantic cod (*Gadus morhua*) from the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys (BTS). *Note that the NEFSC spring survey did not begin until 1968 and the NEFSC fall 2014 survey has not been conducted at the time of this report.*

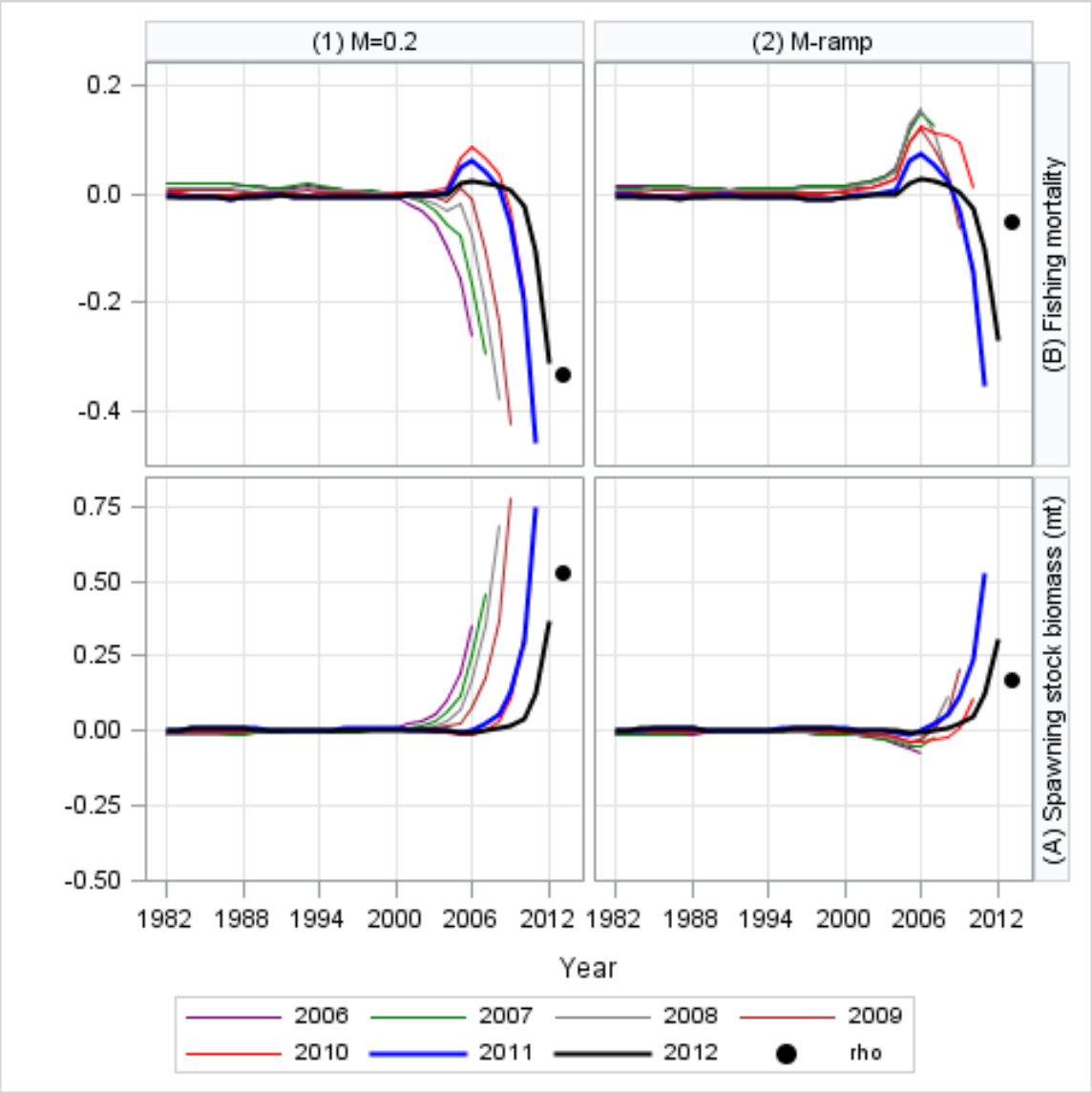

Figure B2. Relative model retrospective error for the Gulf of Maine Atlantic cod (*Gadus morhua*) M=0.2 and M-ramp assessment models. The black circles indicate the Mohn's rho value based on a seven year retrospective peel.

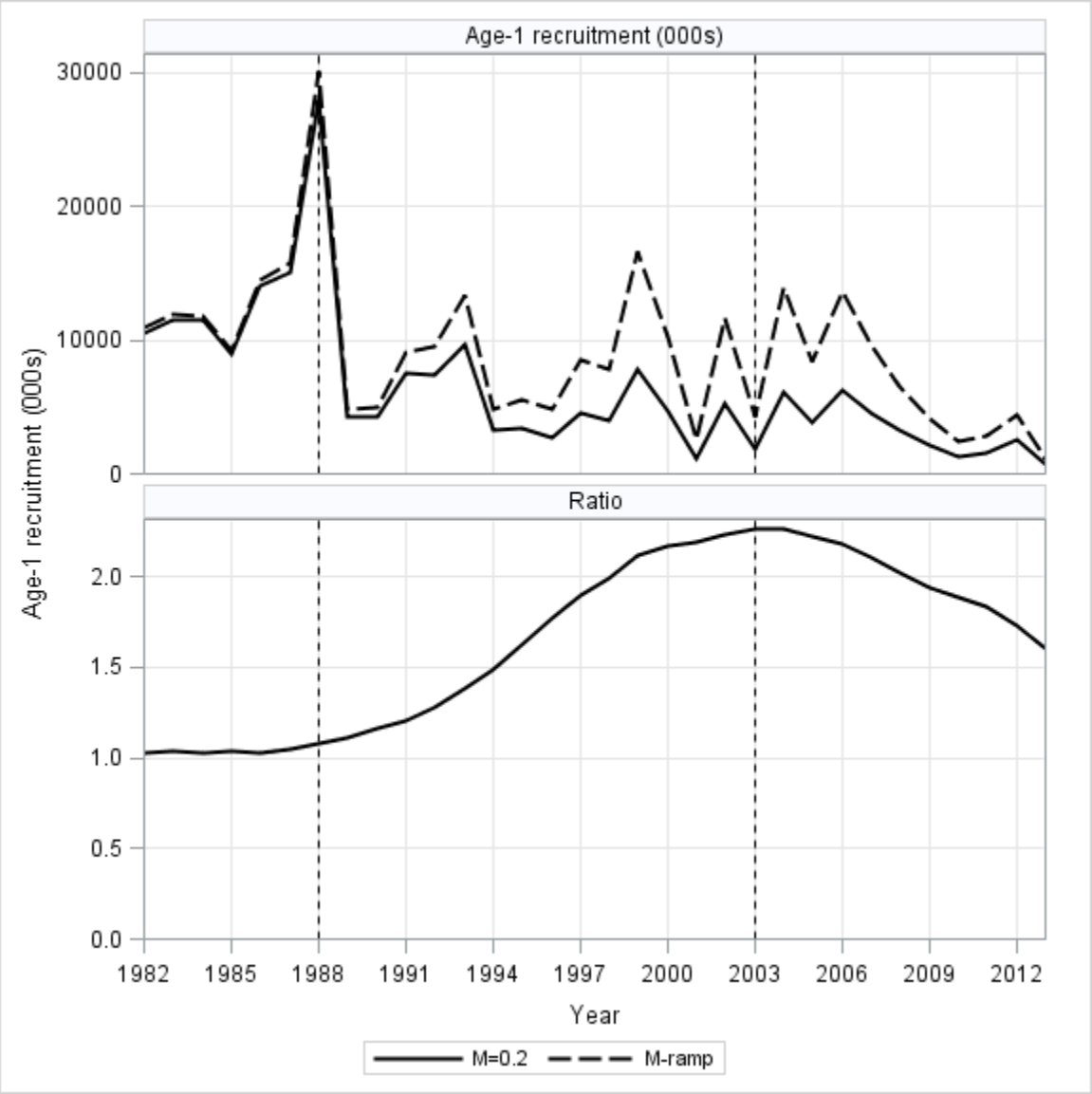

Figure B3. Comparison of the age-1 recruitment estimates from the Gulf of Maine Atlantic cod (*Gadus morhua*) M=0.2 and M-ramp assessment models (top) and the ratio of the M-ramp to the M=0.2 estimated recruitment (bottom). The increased recruitment in the M-ramp model is a function of the increase in natural mortality from M=0.2 pre-1989 to M=0.4 post-2002.

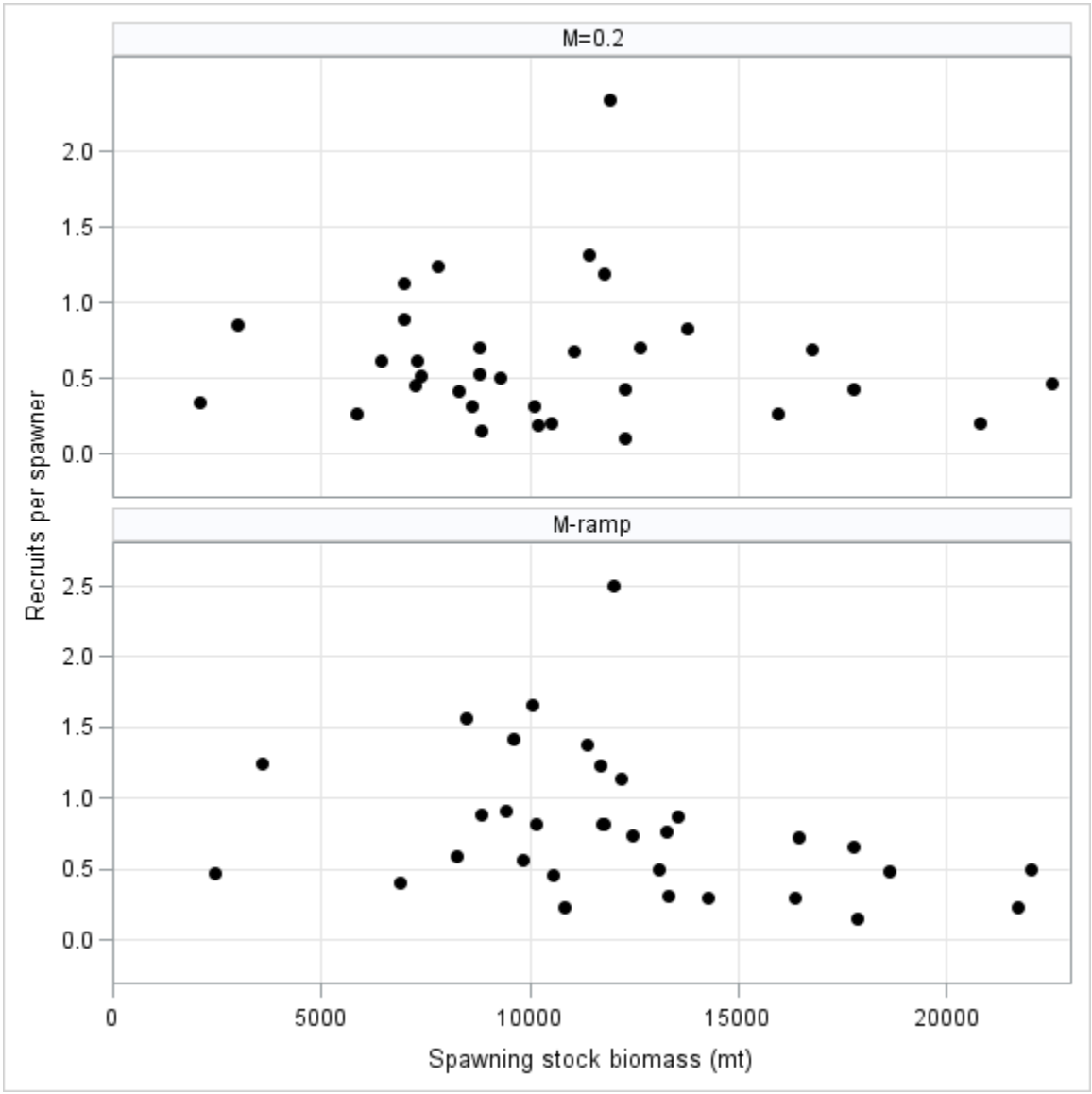

Figure B4. Comparison of Gulf of Maine Atlantic cod (*Gadus morhua*) recruits per spawner to spawning stock biomass as estimated from the M=0.2 and M-ramp assessment models.

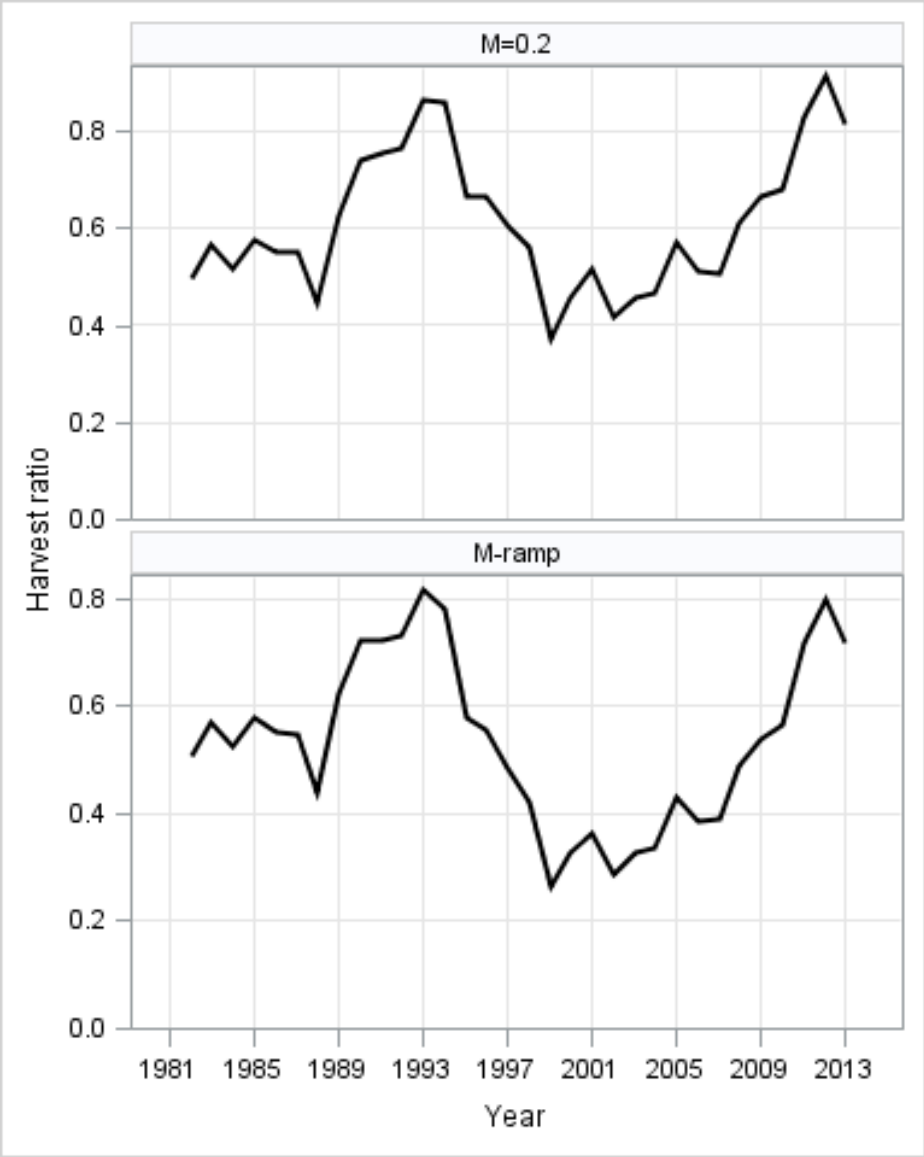

Figure B5. Gulf of Maine Atlantic cod (*Gadus morhua*) harvest ratios (catch/exploitable biomass) as estimated from the M=0.2 and M-ramp assessment models.

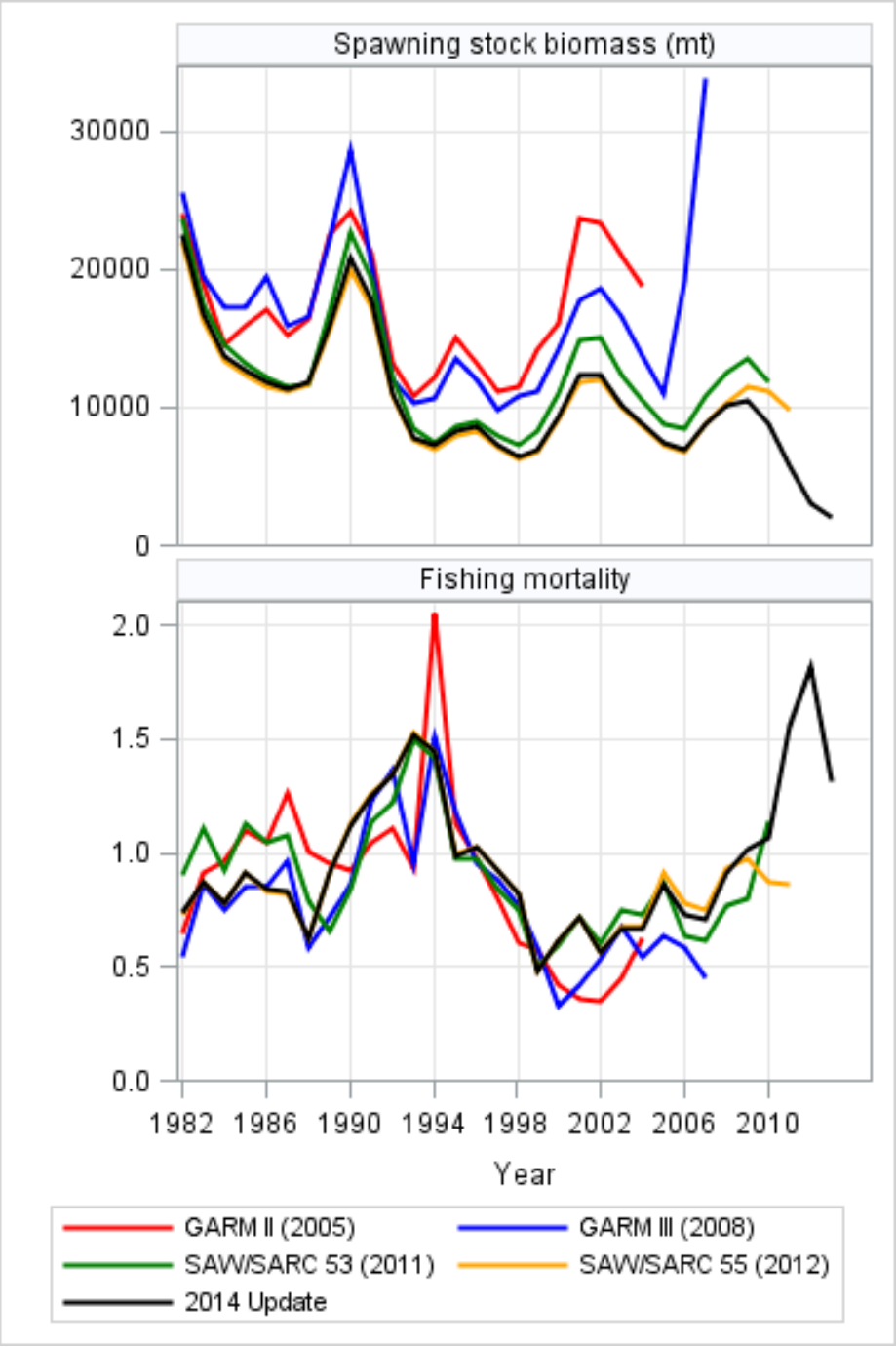

Figure B6. Comparison of estimates of average spawning stock biomass and fishing mortality from previous Gulf of Maine Atlantic cod (*Gadus morhua*) stock assessments since 2005. *Note that results are only shown for the SAW/SARC 55 and 2014 Update M=0.2 models; the basis for fishing mortality varies across assessments; GARM II: average ages 4-5, GARM III: average ages 5-7, SAW/SARC 53, 55 and 2014 Update: fully recruited fishing mortality (F_{full}).*

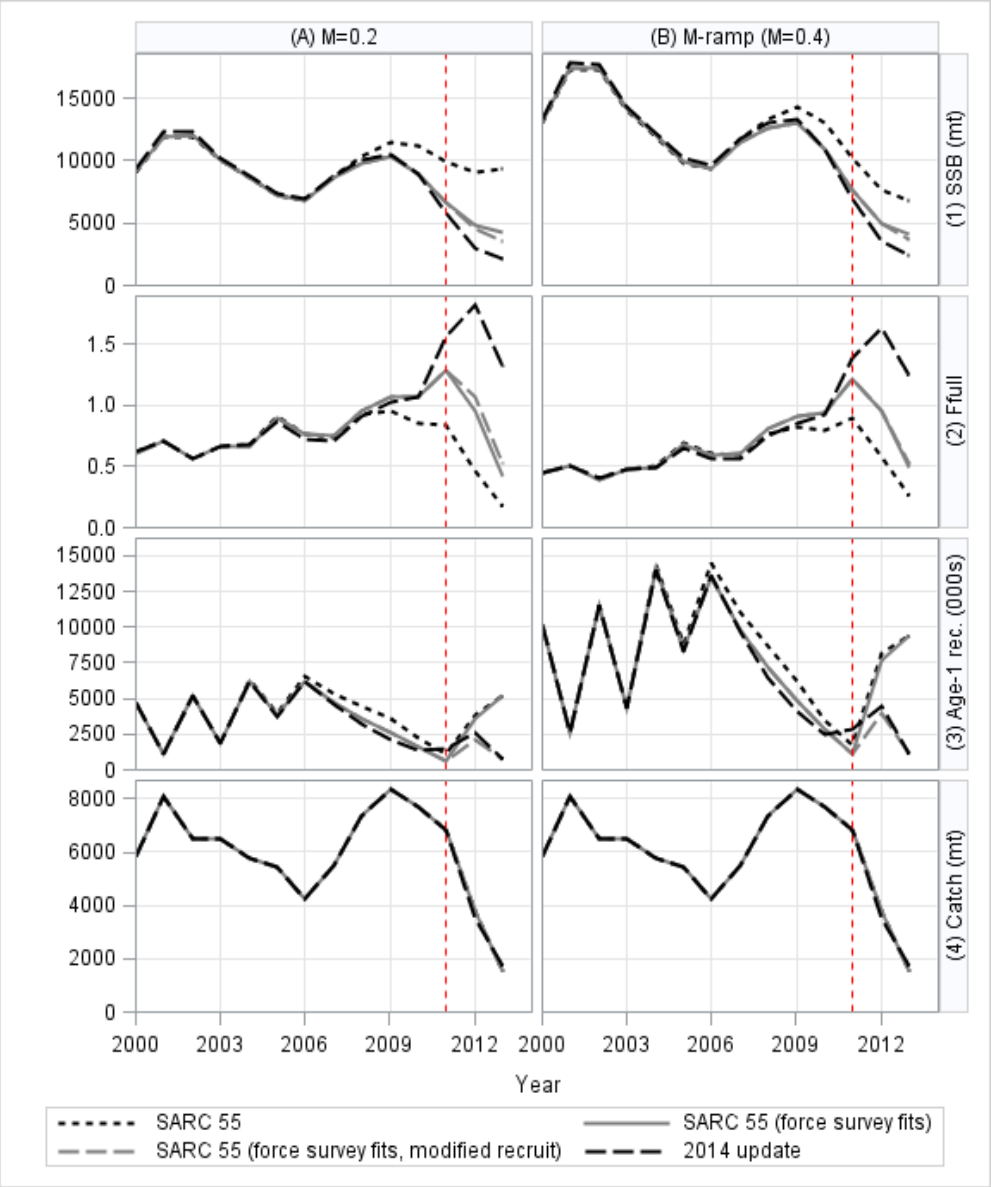

Figure B7. Comparison of the Gulf of Maine Atlantic cod (*Gadus morhua*) SARC 55 assessment results and resulting projections to the 2014 Update results for both the M=0.2 and M-ramp assessment models. The SARC 55 projections assumed catches of 3,767 mt in 2012 and 1,550 mt in 2013. SARC 55 projected recruitment was modeled assuming the geometric mean of 2000-2009 age-1 recruitment for 2012 and 1982-2009 median recruitment for 2013. Sensitivity runs of the SARC 55 model and projections were also conducted where the SARC 55 model was forced to fit the 2010 and 2011 survey indices by setting the coefficients of variation on these years at 0.1. Two projection variations of this sensitivity were conducted: 1) recruitment assumptions identical to the base SARC 55 projections, and 2) geometric mean of 2007-2011 age-1 recruitment for 2012 and the 2013 estimated age-1 recruitment from the 2014 Update (M=0.2: 708,000 fish and M-ramp: 1,131,000 fish).

Procedures for Issuing Manuscripts in the *Northeast Fisheries Science Center Reference Document* (CRD) Series

Clearance

All manuscripts submitted for issuance as CRDs must have cleared the NEFSC's manuscript/abstract/webpage review process. If any author is not a federal employee, he/she will be required to sign an "NEFSC Release-of-Copyright Form." If your manuscript includes material from another work which has been copyrighted, then you will need to work with the NEFSC's Editorial Office to arrange for permission to use that material by securing release signatures on the "NEFSC Use-of-Copyrighted-Work Permission Form."

For more information, NEFSC authors should see the NEFSC's online publication policy manual, "Manuscript/abstract/webpage preparation, review, and dissemination: NEFSC author's guide to policy, process, and procedure," located in the Publications/Manuscript Review section of the NEFSC intranet page.

Organization

Manuscripts must have an abstract and table of contents, and (if applicable) lists of figures and tables. As much as possible, use traditional scientific manuscript organization for sections: "Introduction," "Study Area" and/or "Experimental Apparatus," "Methods," "Results," "Discussion," "Conclusions," "Acknowledgments," and "Literature/References Cited."

Style

The CRD series is obligated to conform with the style contained in the current edition of the United States Government Printing Office Style Manual. That style manual is silent on many aspects of scientific manuscripts. The CRD series relies more on the CSE Style Manual. Manuscripts should be prepared to conform with these style manuals.

The CRD series uses the American Fisheries Society's guides to names of fishes, mollusks, and decapod crustaceans, the Society for Marine Mammalogy's guide to names of marine mammals, the Biosciences Information Service's guide to serial title abbreviations, and the ISO's (International Standardization Organization) guide to statistical terms.

For in-text citation, use the name-date system. A special effort should be made to ensure that all necessary bibliographic information is included in the list of cited works. Personal communications must include date, full name, and full mailing address of the contact.

Preparation

Once your document has cleared the review process, the Editorial Office will contact you with publication needs – for example, revised text (if necessary) and separate digital figures and tables if they are embedded in the document. Materials may be submitted to the Editorial Office as files on zip disks or CDs, email attachments, or intranet downloads. Text files should be in Microsoft Word, tables may be in Word or Excel, and graphics files may be in a variety of formats (JPG, GIF, Excel, PowerPoint, etc.).

Production and Distribution

The Editorial Office will perform a copy-edit of the document and may request further revisions. The Editorial Office will develop the inside and outside front covers, the inside and outside back covers, and the title and bibliographic control pages of the document.

Once both the PDF (print) and Web versions of the CRD are ready, the Editorial Office will contact you to review both versions and submit corrections or changes before the document is posted online.

A number of organizations and individuals in the Northeast Region will be notified by e-mail of the availability of the document online.

Research Communications Branch
Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
166 Water St.
Woods Hole, MA 02543-1026

MEDIA MAIL

Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "conducting ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources and to generate social and economic opportunities and benefits from their use." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Currently, there are three such media:

NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term field or lab studies of important species or habitats; synthesis reports for important species or habitats; annual reports of overall assessment or monitoring programs; manuals describing program-wide surveying or experimental techniques; literature surveys of important species or habitat topics; proceedings and collected papers of scientific meetings; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

Northeast Fisheries Science Center Reference Document -- This series is issued irregularly. The series typically includes: data reports on field and lab studies; progress reports on experiments, monitoring, and assessments; background papers for, collected abstracts of, and/or summary reports of scientific meetings; and simple bibliographies. Issues receive internal scientific review and most issues receive copy editing.

Resource Survey Report (formerly *Fishermen's Report*) -- This information report is a regularly-issued, quick-turnaround report on the distribution and relative abundance of selected living marine resources as derived from each of the NEFSC's periodic research vessel surveys of the Northeast's continental shelf. This report undergoes internal review, but receives no technical or copy editing.

TO OBTAIN A COPY of a *NOAA Technical Memorandum NMFS-NE* or a *Northeast Fisheries Science Center Reference Document*, either contact the NEFSC Editorial Office (166 Water St., Woods Hole, MA 02543-1026; 508-495-2350) or consult the NEFSC webpage on "Reports and Publications" (http://www.nefsc.noaa.gov/nefsc/publications/). To access *Resource Survey Report*, consult the Ecosystem Surveys Branch webpage (http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage/).

ANY USE OF TRADE OR BRAND NAMES IN ANY NEFSC PUBLICATION OR REPORT DOES NOT IMPLY ENDORSEMENT.