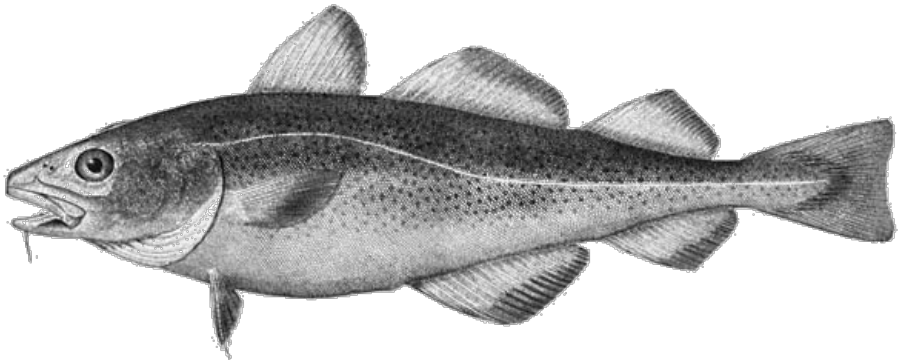
Gulf of Maine Atlantic cod

Michael Palmer
NEFSC/Population Dynamics Branch



Groundfish Operational Assessment Meeting
September 14-18, 2015
Woods Hole, MA

2015 Assessment Update: Presentation Overview

- Overview of the previous stock assessment (2014)
- Major signals in the fishery and survey data
  - Model independent evaluation of stock condition
- Data assembly, modelling, reference point and projection approach
- Assessment data inputs and changes from the 2014 assessment
- Model diagnostics and results
- Updated biological reference points and stock status
- Preliminary short-term (2016-2018) catch and biomass projections

2014 Assessment Update

- Stock Status

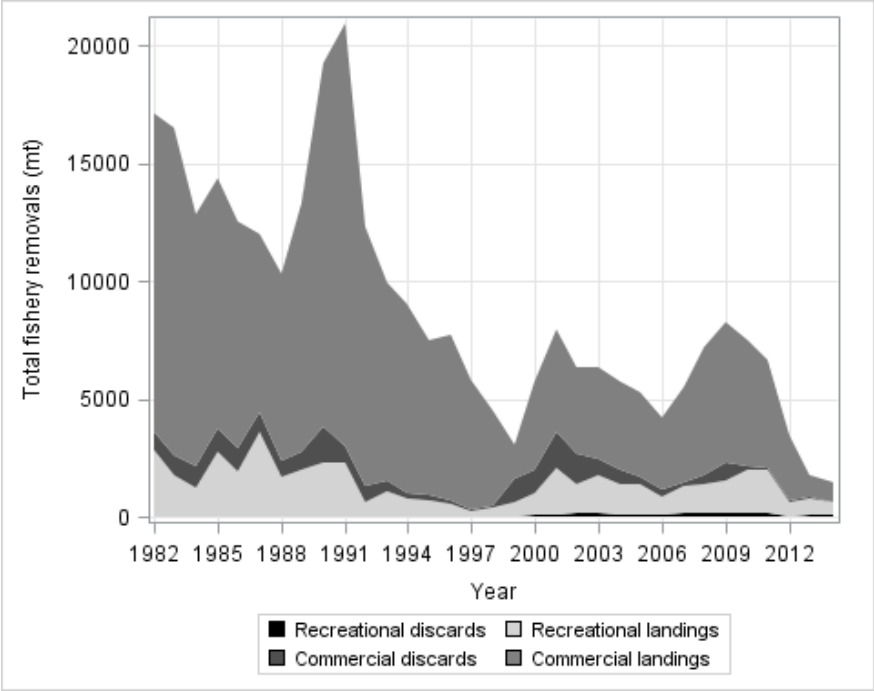
Assessment	Proxy reference points	M=0.2	M-ramp
2014 update	$F_{full,\ 2013}$	1.33 (0.89 - 1.92)	1.24 (0.84 - 1.78)
	F_{MSY}	0.18	0.18
	$F_{full,\ 2013}/F_{MSY}$	7.39	6.89
	Overfishing	Yes	Yes
	SSB_{2013} (mt)	2,063 (1,561 - 2,774)	2,432 (1,819 - 3,230)
	SSB_{MSY} (mt)	47,184 (32,903 - 67,045)	69,621 (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)

- Issues and uncertainties:
  - Two accepted models (M=0.2, M-ramp), overall uncertainty in current natural mortality
  - M=0.2 model exhibited major retrospective patter, M-ramp had minor retrospective pattern
  - Recent low recruitment compromises rebuilding potential of the stock

Adapted from Table 40

Overview of Fishery and Survey Data

- Fishery: catch source



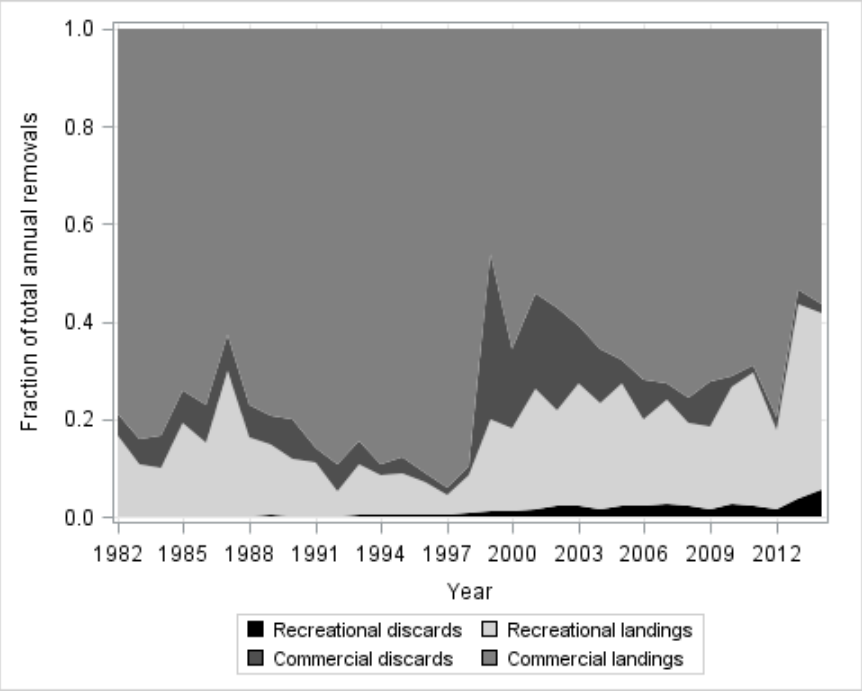
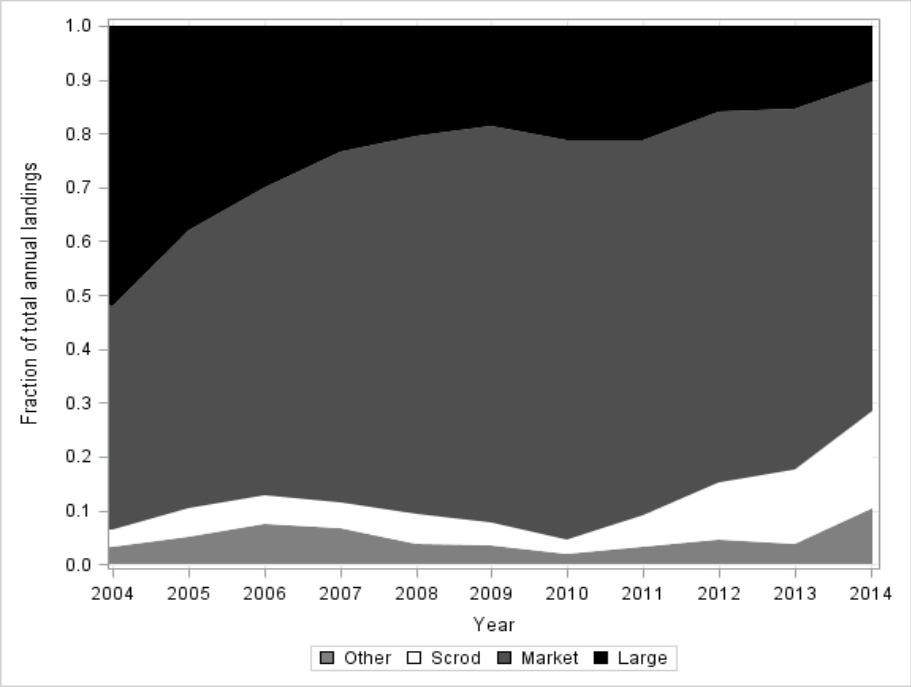
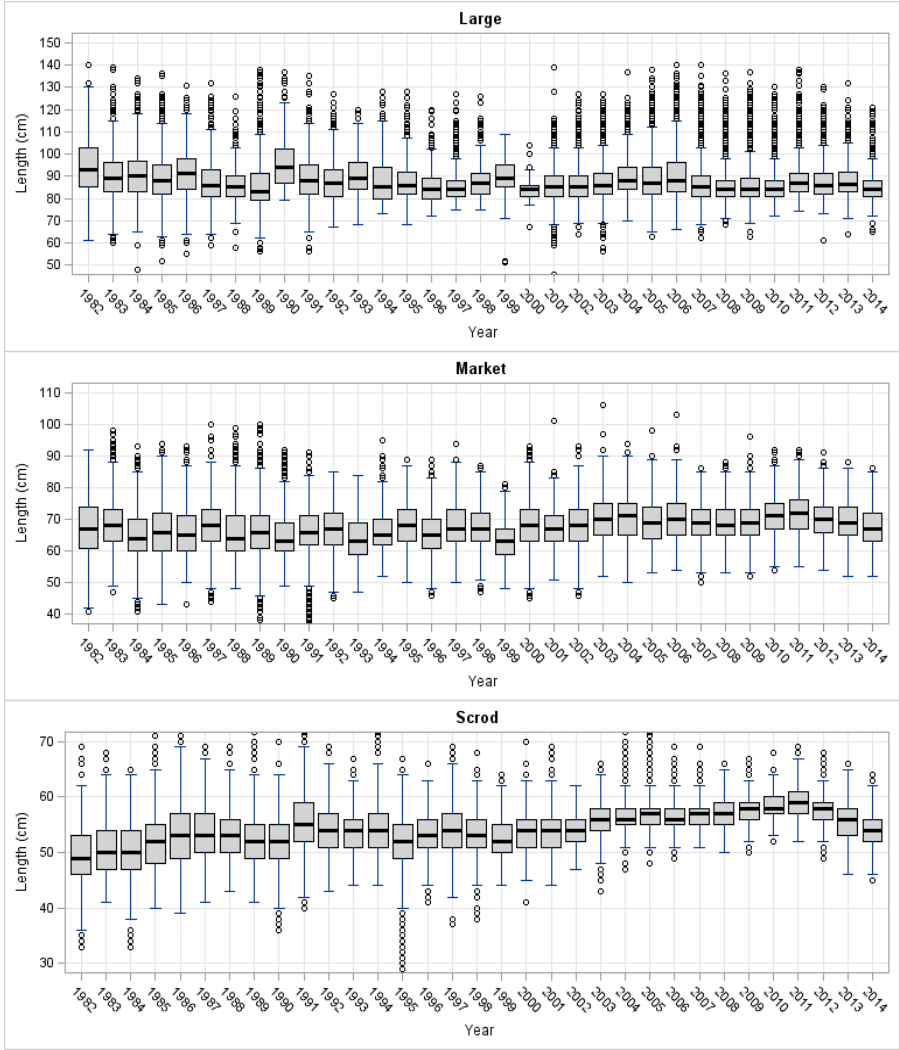


Figure 5

Overview of Fishery and Survey Data

- Fishery: commercial length distributions





Figures 11, 12

Overview of Fishery and Survey Data

- Fishery: recreational length distributions

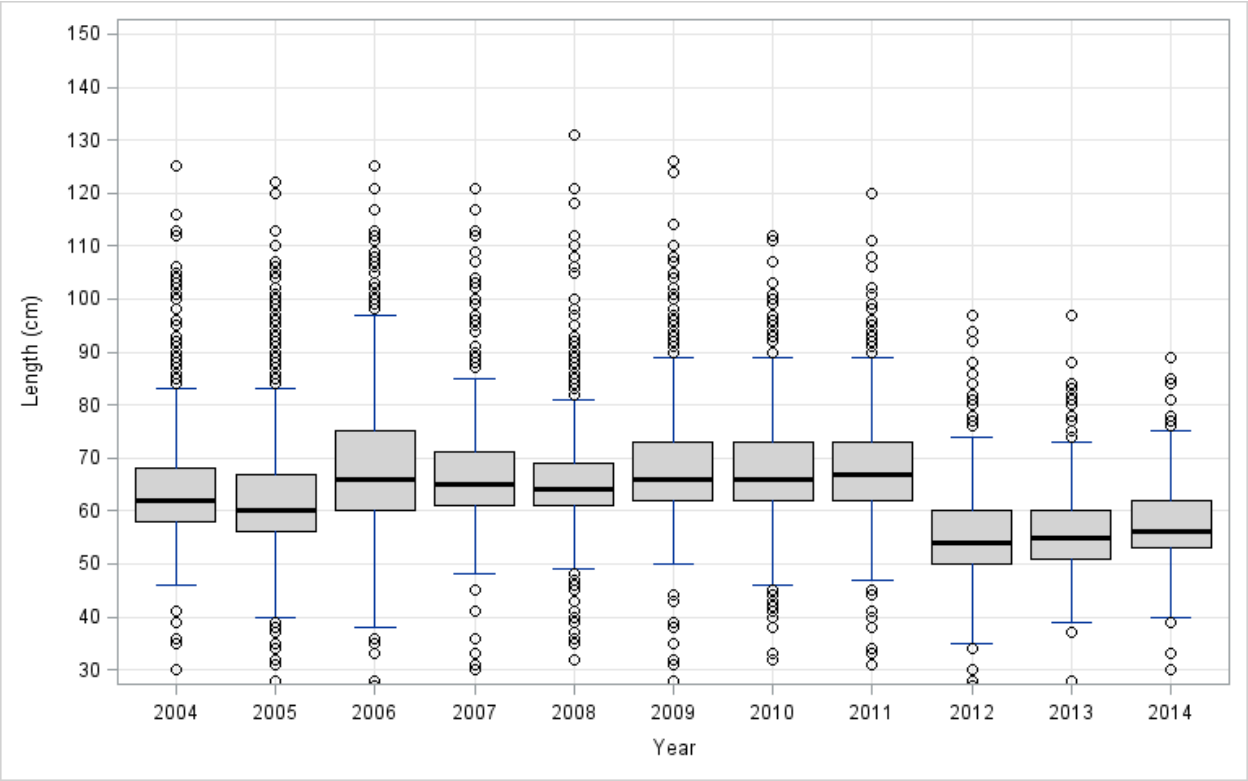
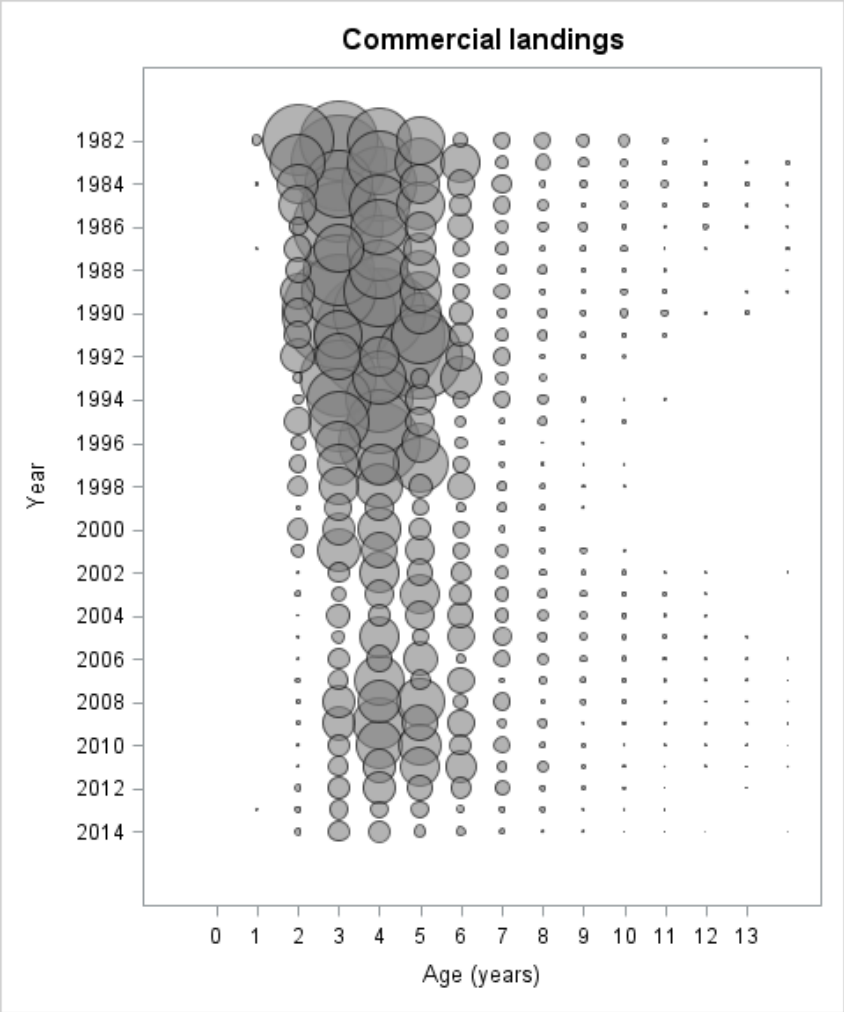
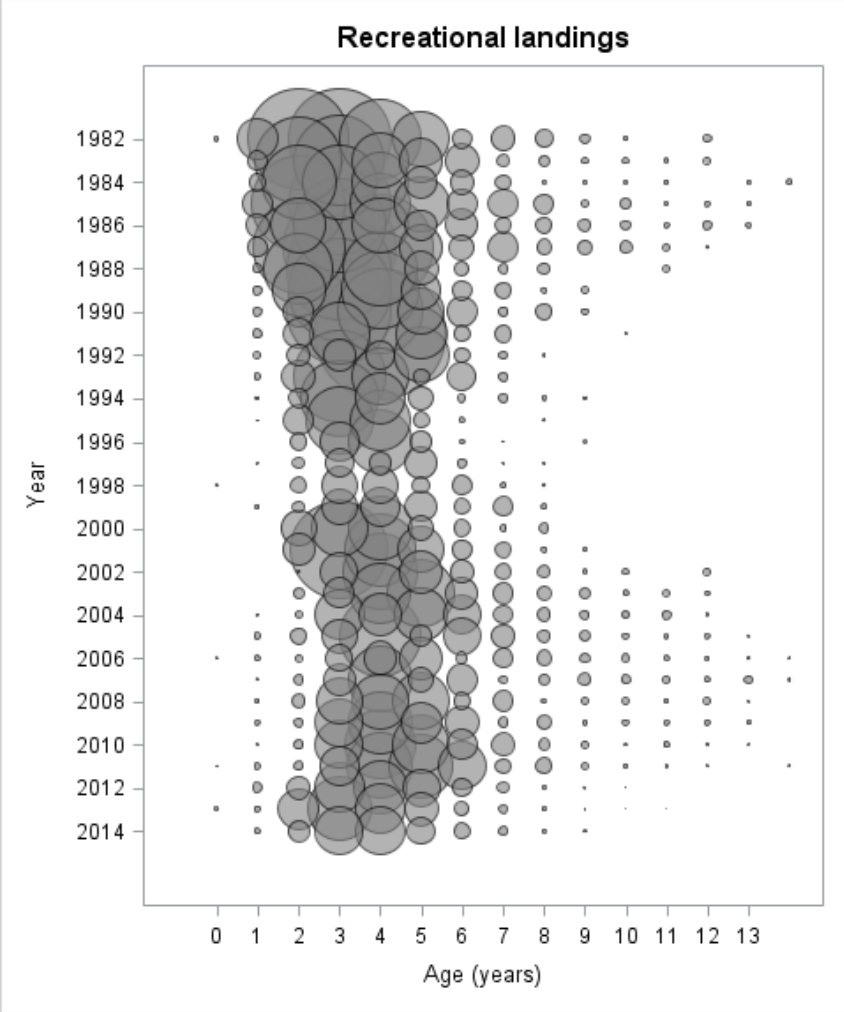


Figure 15

Overview of Fishery and Survey Data

- Fishery: commercial and recreational age structure:

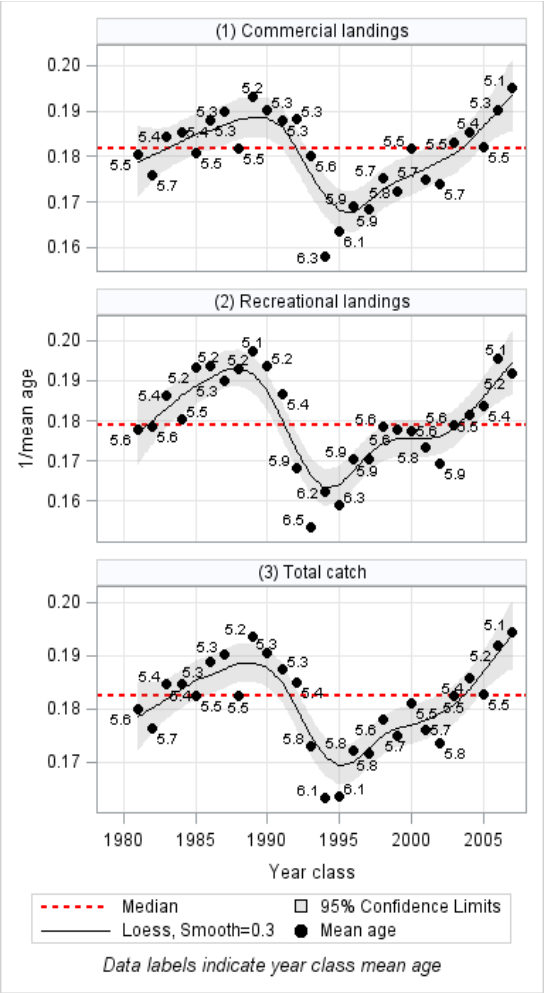


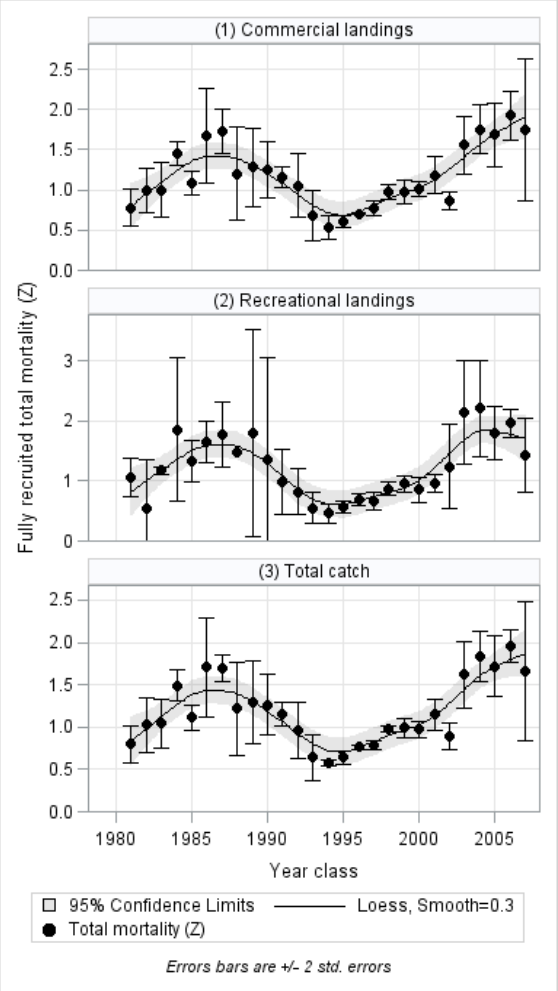


Figures 16, 18

Overview of Fishery and Survey Data

- Fishery: mean age and catch-curve estimated total mortality (Z)





Figures 21, 22

Overview of Fishery and Survey Data

- Survey: aggregate indices

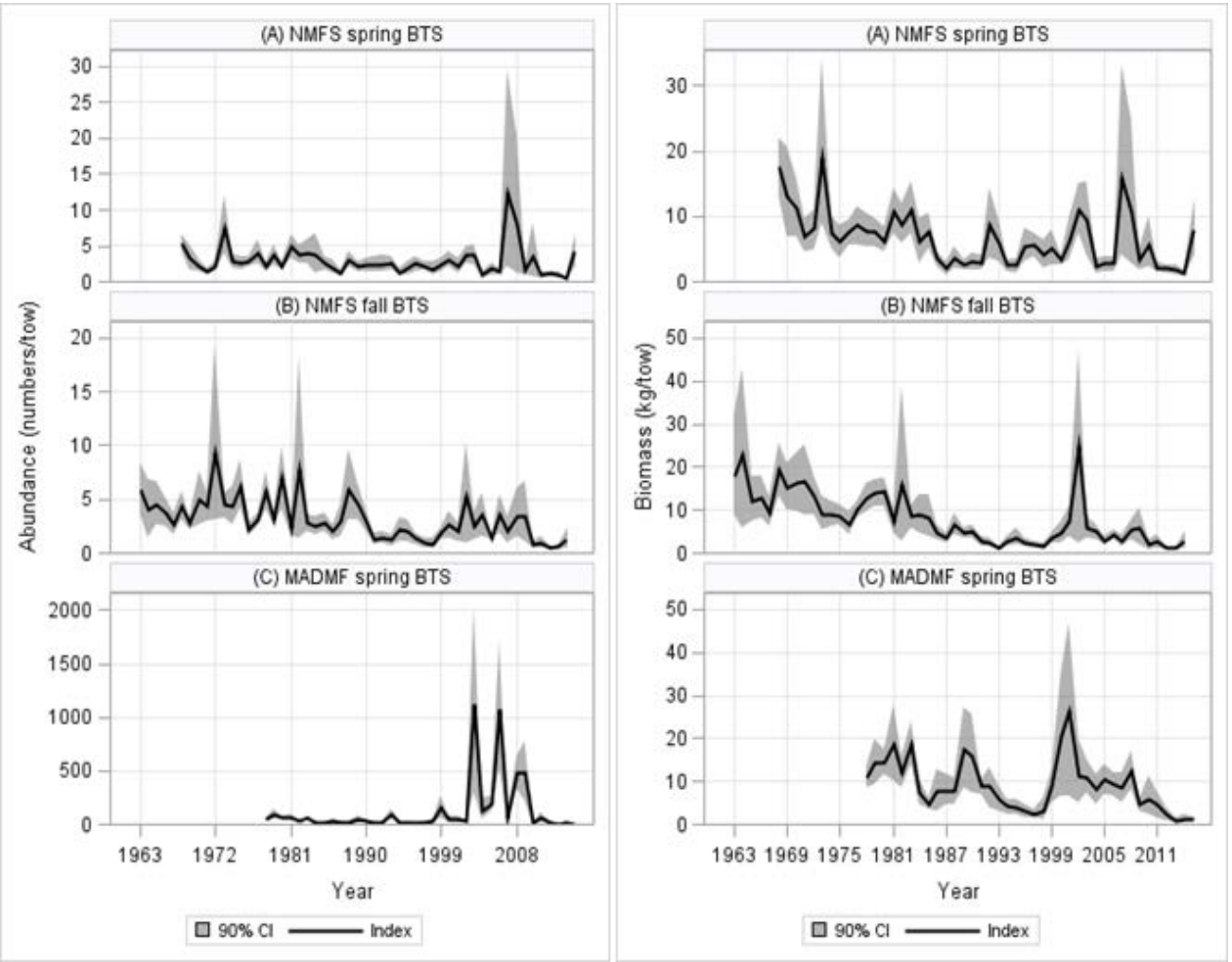
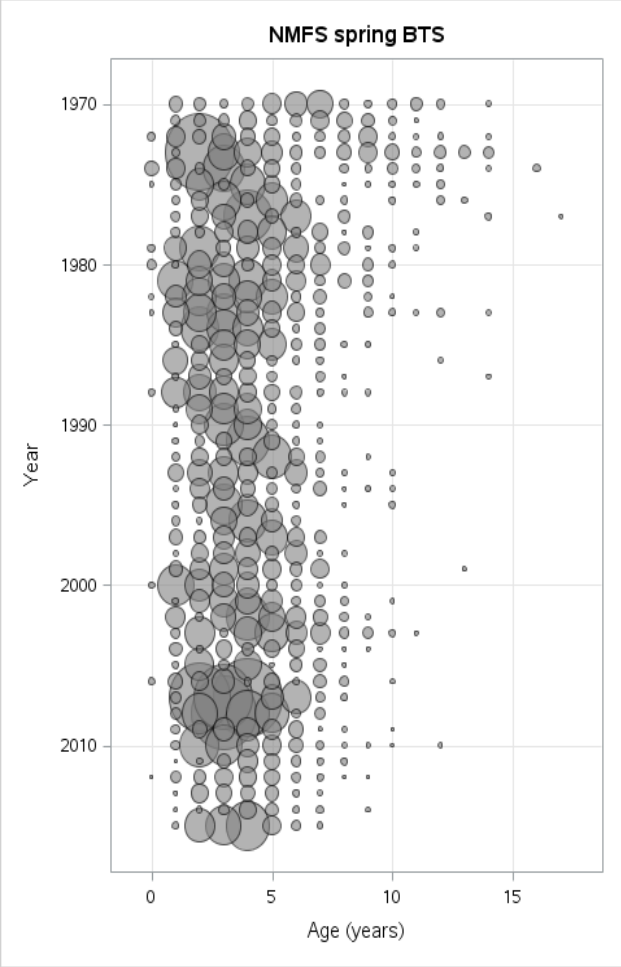
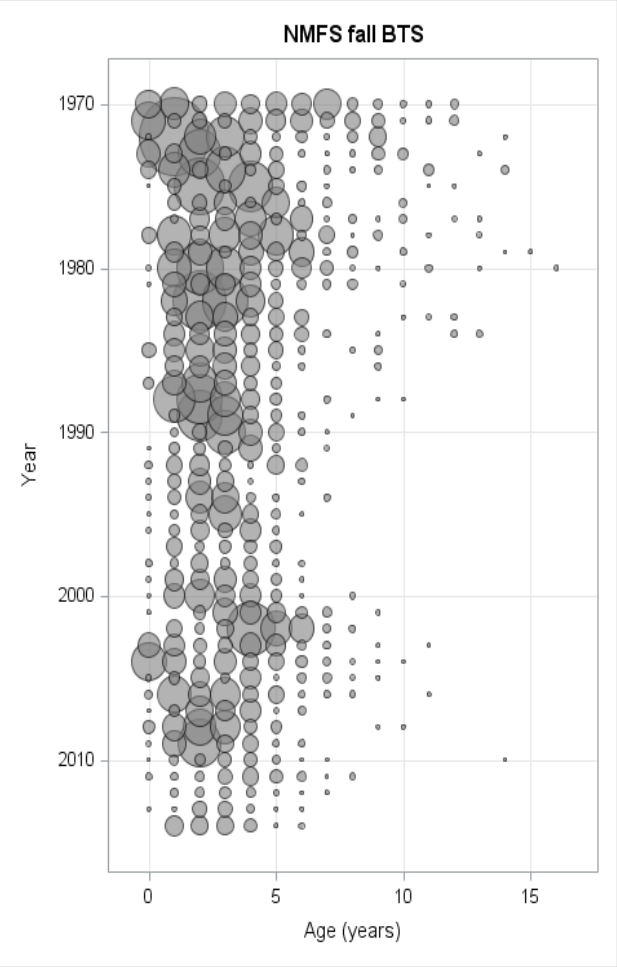


Figure 32

Overview of Fishery and Survey Data

- Survey: indices-at-age

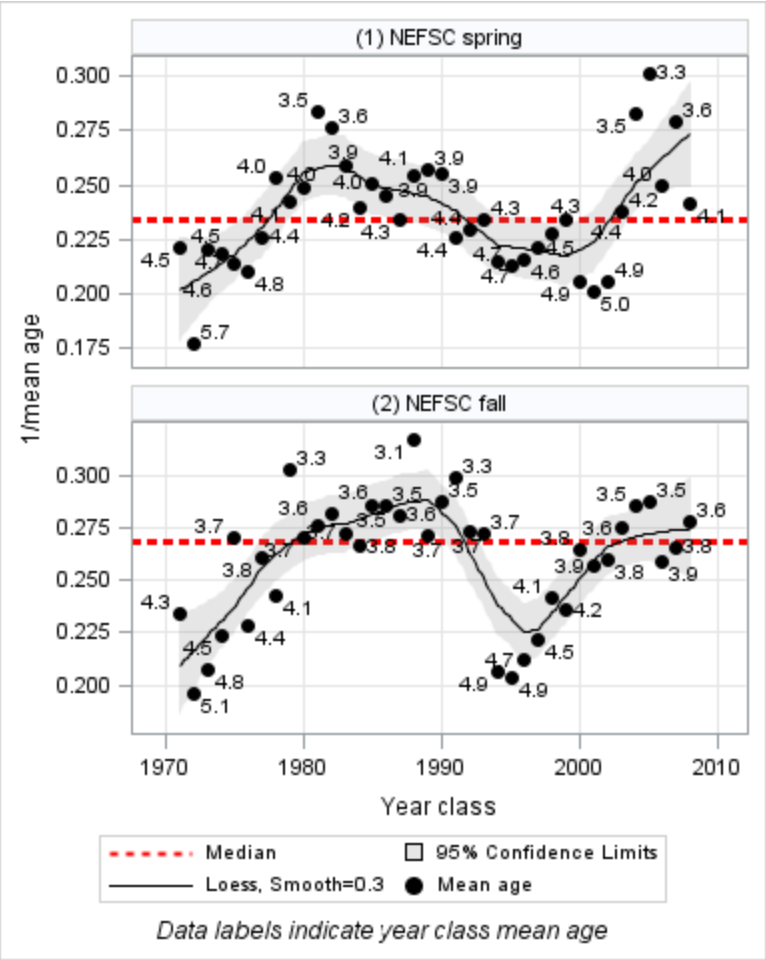


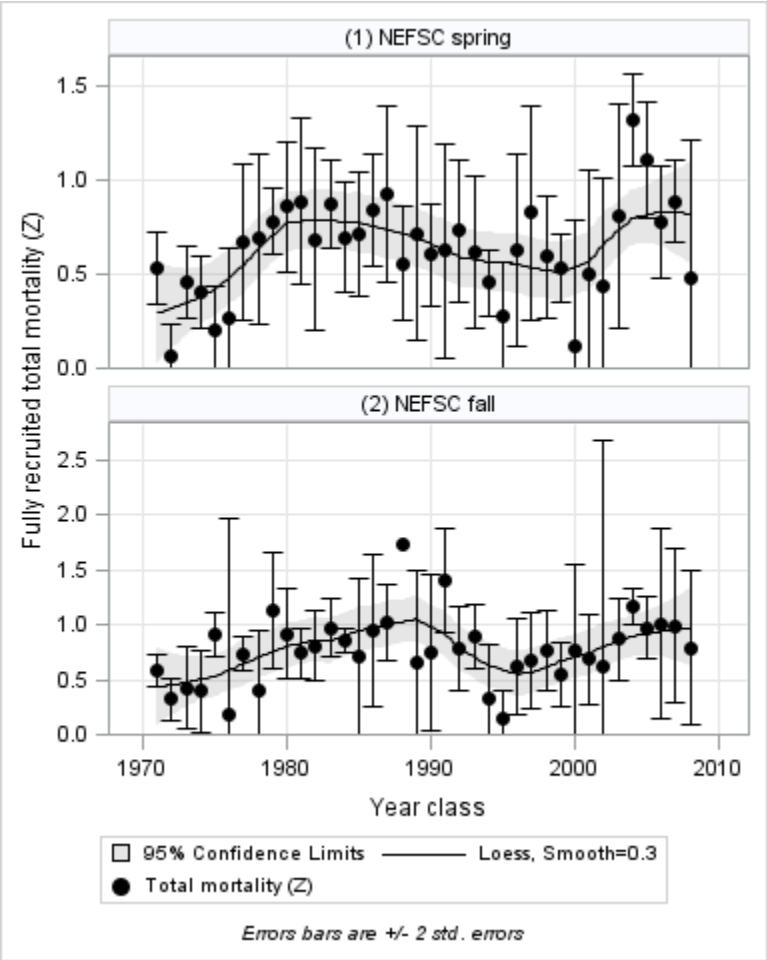


Figures 36-38

Overview of Fishery and Survey Data

- Survey: mean age and catch-curve estimated total mortality (Z)

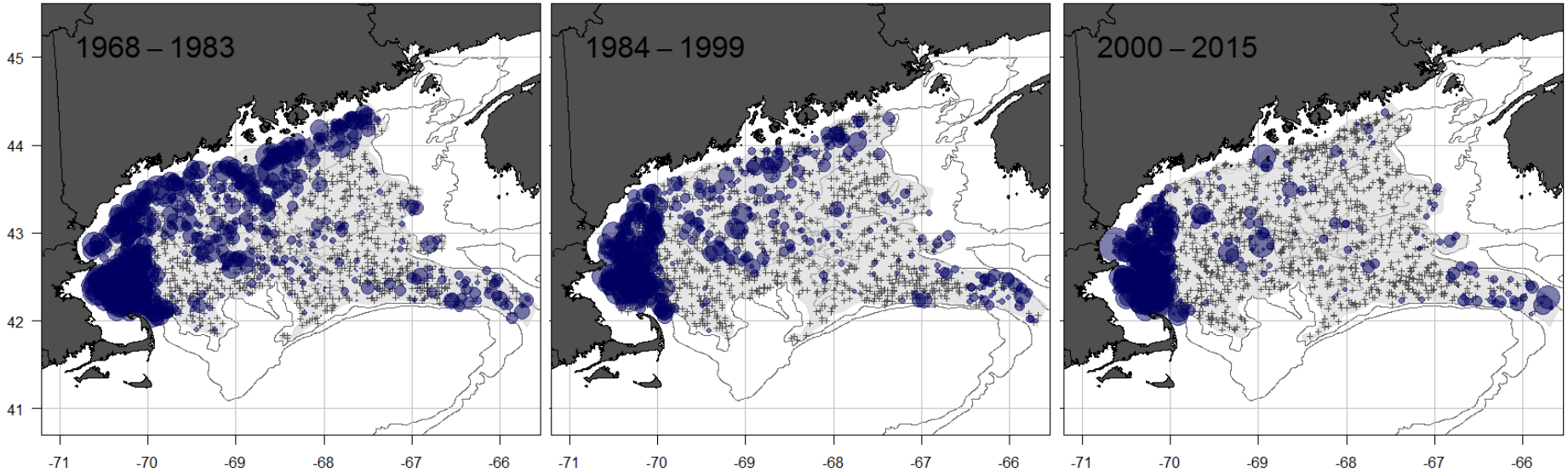


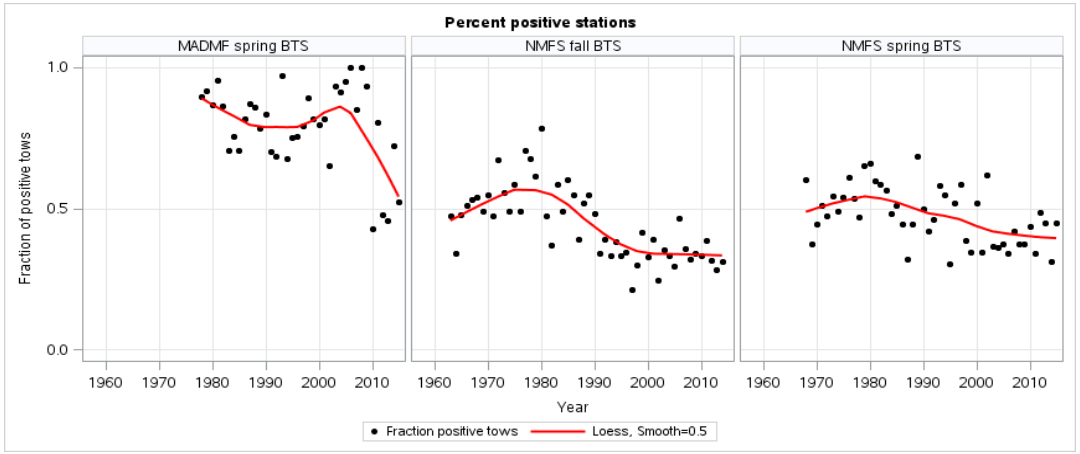


Figures 39, 40

Overview of Fishery and Survey Data

- Survey: spatial distribution





Figures 41, 45

2015 Assessment Update Overview

- Incorporate an additional year of data (2014) into the 2014 assessment time series
  - Minor changes:
    - Switch NEFSC survey station acceptance criterion from SHG to TOGA
    - Update of MRIP catch estimates to reflect data updates
    - Revise the discard mortality assumption for the recreational fishery from 30% to 15% following Capizzano et al. study

- Update the SAW/SARC 55 ASAP models through 2014
  - Minor changes:
    - Maturity-at-age time series: 1977 start year → 1982 start year (2014 update)
    - Turn ASAP likelihood constants off (this update, minimal impact – see Fig. 52)

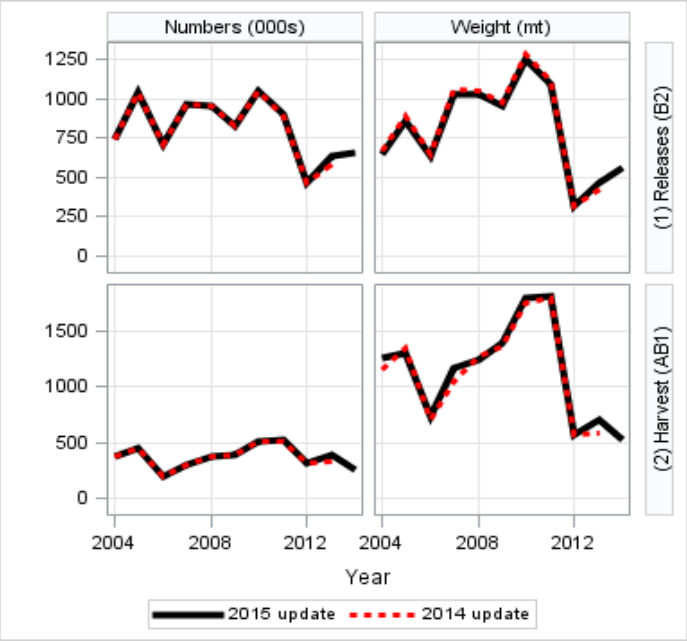
- Update F_{MSY} proxies ($F_{40\%}$)
  - Use recent 3-year average weights

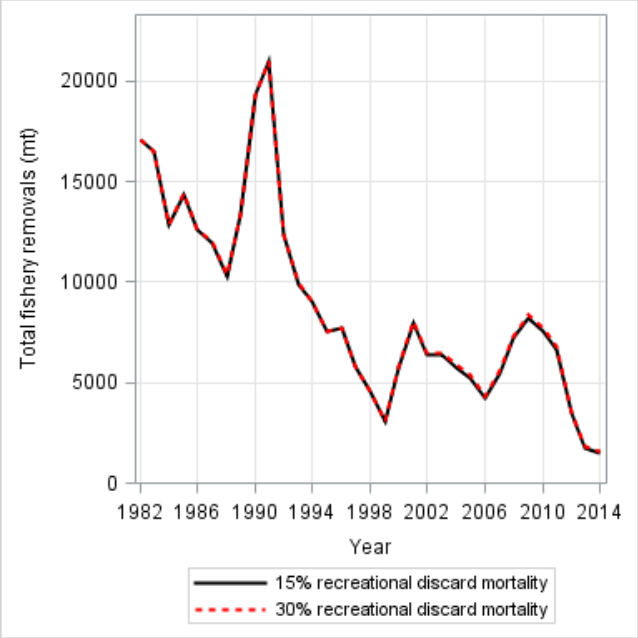
- Update SSB_{MSY} proxies

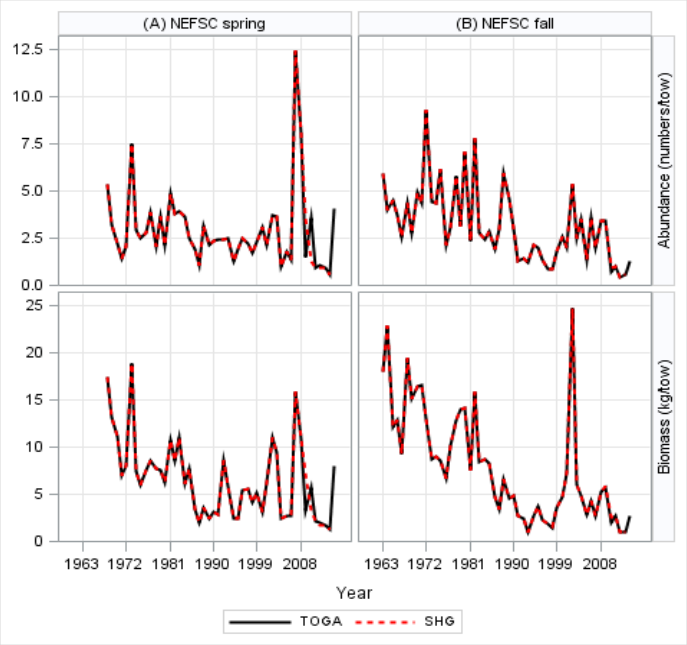
- Update short-term projections (2016-2018)

Model Inputs

- Data changes:
  - MRIP updates (upper right)
  - Change in NEFSC survey station acceptance criterion (lower right)
  - Revised discard mortality rates (lower left)







Figures 6, 13, 33

Model Inputs

- Biology
  - Maturity-at-age (1982-2014 time series average)
  - Assumed natural mortality (M=0.2 or M-ramp from 0.2→0.4)
  - Stock weights-at-age

- Fishery catches
  - Commercial landings and discards (ages 1-9^+)
    - Discard mortality rate varies by gear
  - Recreational landings and discards (ages 1-9^+)
    - Discard mortality rate = 15%
  - Catch weights-at-age

- Survey
  - NEFSC spring and fall (ages 1-9^+)
  - MADMF spring (ages 1-6)

Model Formulation

- Model formulation:
  - Years: 1982-2014
  - Fishery:
    - Single fleet (combined commercial and recreational)
    - CV = 0.05
    - Selectivity modelled with three selectivity blocks (all single logistic)
      - 1982-1988, 1989-2004, 2005-2014
  - Surveys:
    - CVs from surveys with re-weighting
      - NMFS spring:+0.2, NMFS fall:+0.1, MADMF spring:+0.3
    - Selectivity freely estimated at-age – fixed 6^+ (NEFSC) and 1 (MADMF)
    - Catchability does not vary over time
  - Recruitment modelled as deviations from the mean
    - Lambda=0.2, CV=0.5
  - Two models: M=0.2, M-ramp
    - M=0.2:1982-1988, ramp: 1989-2002, M=0.4: 2003-2014

Model Diagnostics

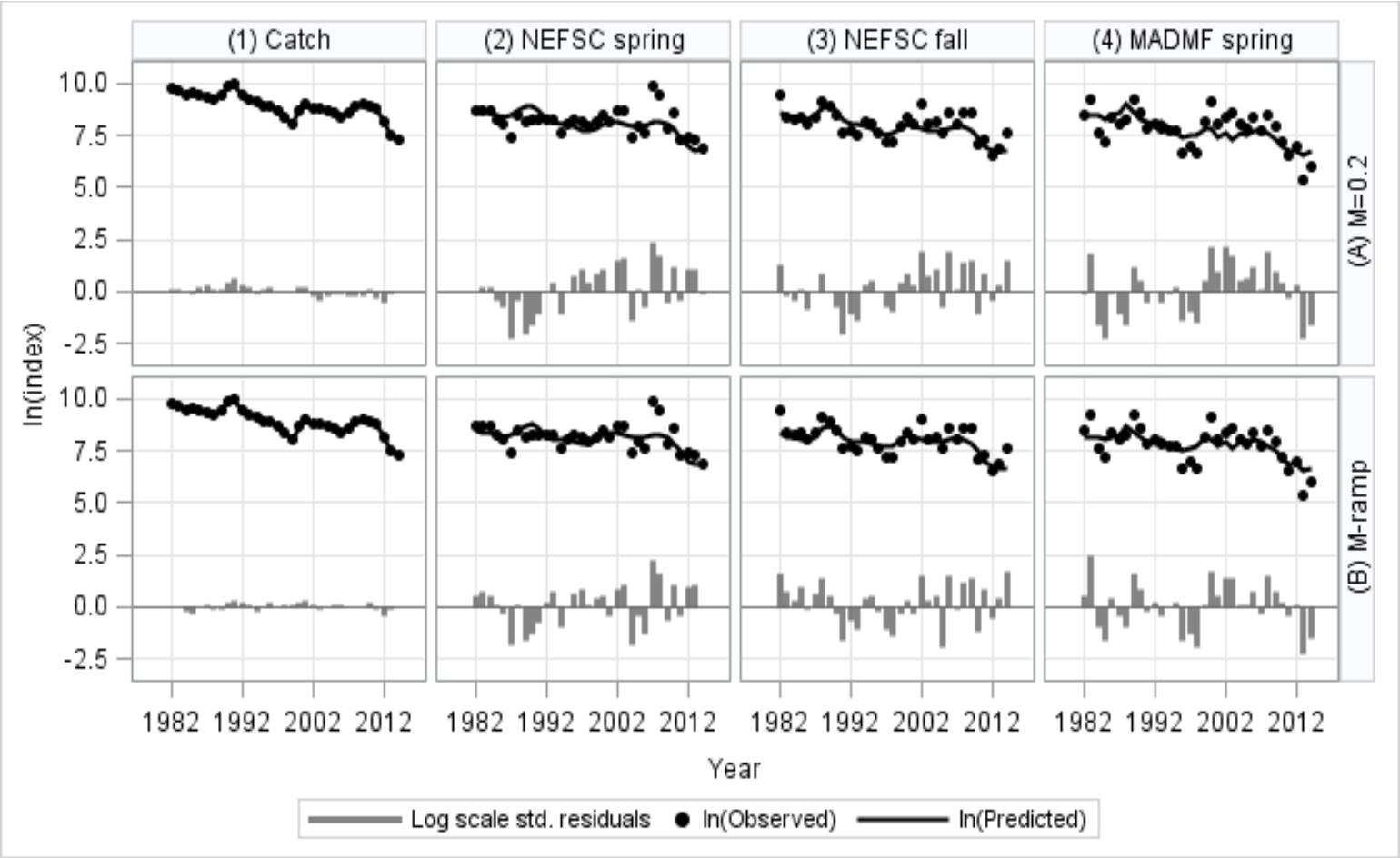
- Selectivity and survey catchability

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}	3.33	*0.02*	3.36	*0.02*
	slope up	0.55	*0.05*	0.52	*0.05*
Block 3 (2005-2014)	A_{50}	3.71	*0.03*	3.76	*0.03*
	slope up	0.55	*0.06*	0.52	*0.06*
NEFSC spring	Age1	0.04	*0.24*	0.03	*0.24*
	Age2	0.14	*0.19*	0.12	*0.19*
	Age3	0.27	*0.18*	0.25	*0.18*
	Age4	0.50	*0.18*	0.48	*0.18*
	Age5	0.72	*0.19*	0.71	*0.19*
	Age6	1.00		1.00	
	Age7	1.00		1.00	
	Age8	1.00		1.00	
	$Age9^+$	1.00		1.00	
NEFSC fall	Age1	0.15	*0.25*	0.12	*0.25*
	Age2	0.34	*0.24*	0.31	*0.24*
	Age3	0.51	*0.24*	0.50	*0.24*
	Age4	0.74	*0.24*	0.74	*0.24*
	Age5	0.86	*0.26*	0.88	*0.26*
	Age6	1.00		1.00	
	Age7	1.00		1.00	
	Age8	1.00		1.00	
	$Age9^+$	1.00		1.00	
MADMF spring	Age1	1.00		1.00	
	Age2	0.71	*0.15*	0.79	*0.15*
	Age3	0.64	*0.17*	0.78	*0.17*
	Age4	0.67	*0.21*	0.86	*0.21*
	Age5	0.73	*0.30*	0.98	*0.30*
	Age6	0.57	*0.56*	0.76	*0.56*
Survey catchability (q)	**NEFSC spring**	1.05 *(0.17)*		0.92 *(0.17)*	
	NEFSC fall	0.66 *(0.23)*		0.56 *(0.23)*	
	MADMF spring	0.22 *(0.12)*		0.15 *(0.12)*	

Table 31

Model Diagnostics

- Model fits to total catch and aggregate survey indices



Model Diagnostics

- Model fits to catch-at-age

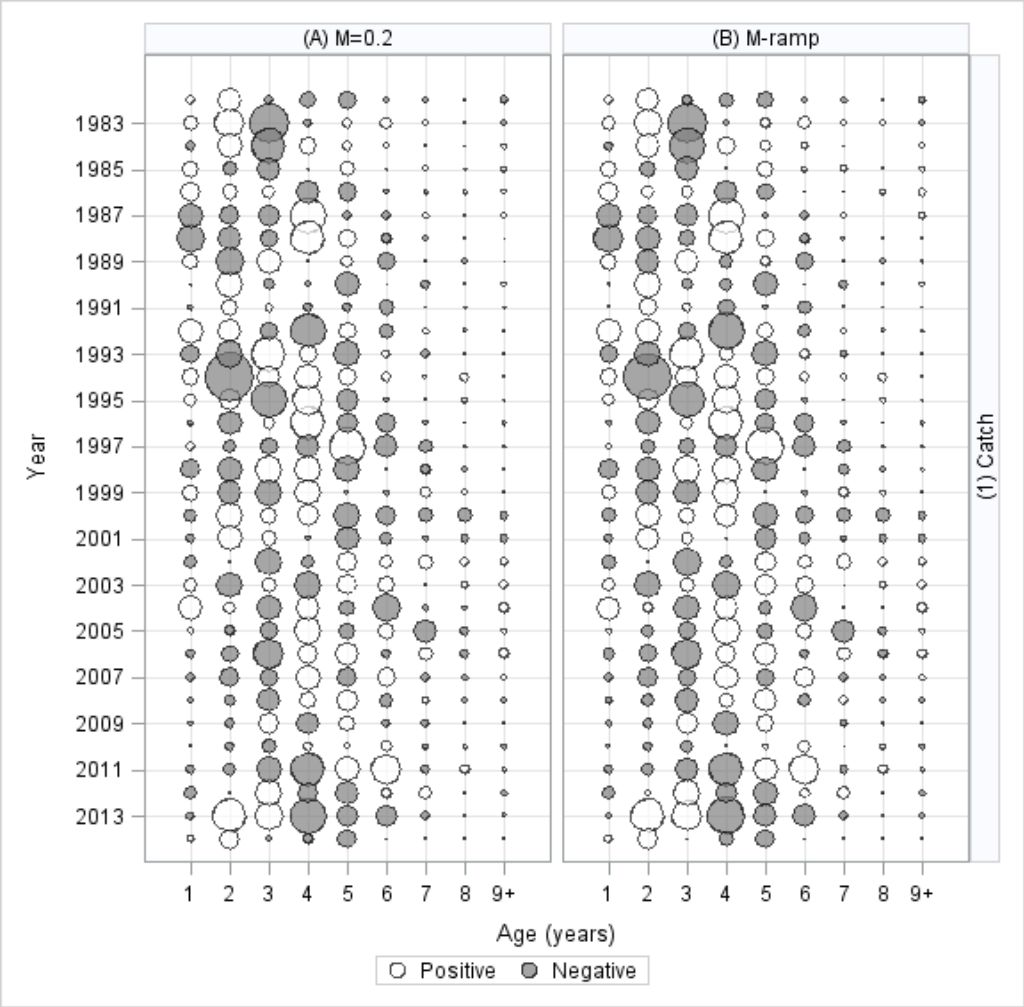
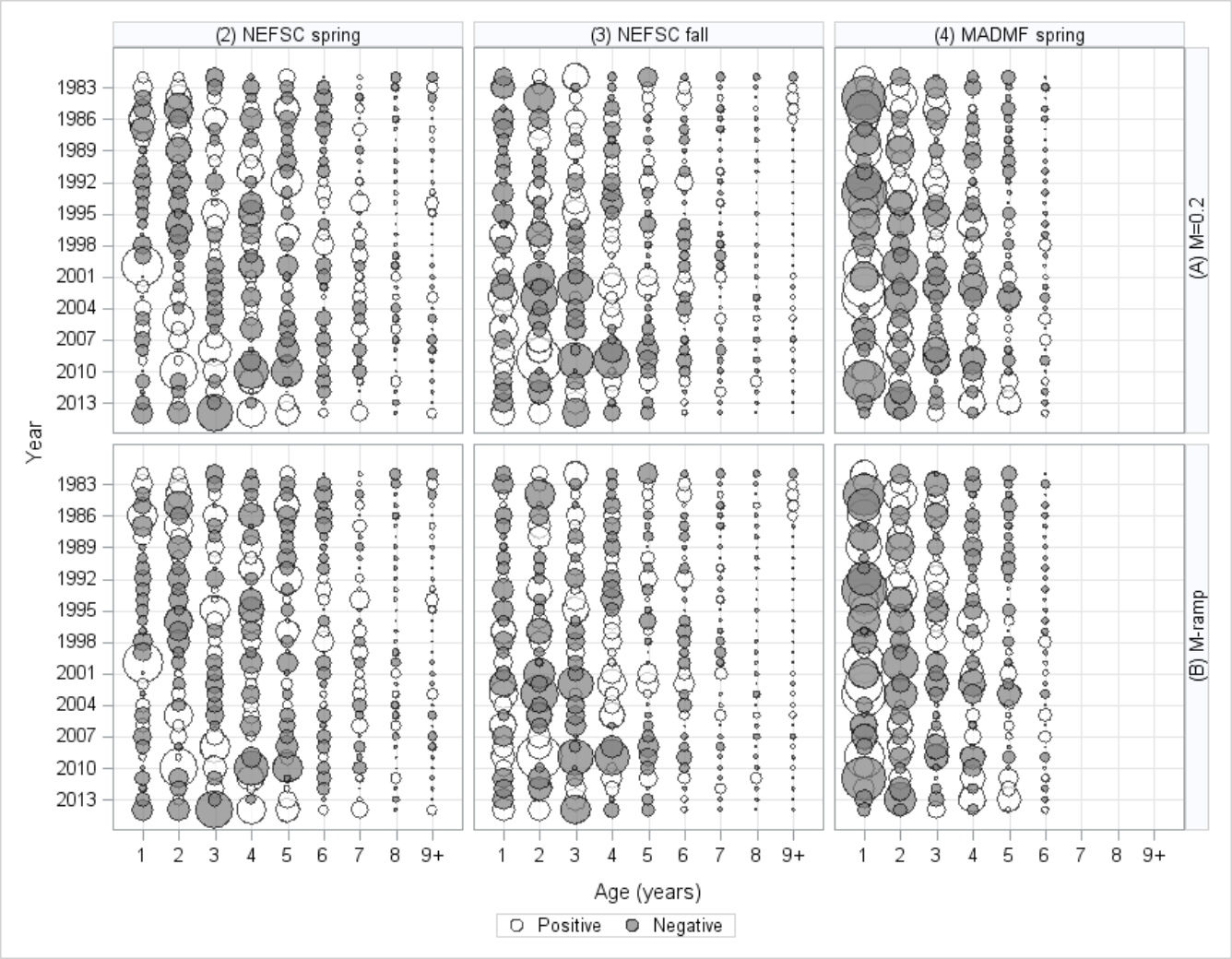


Figure 56

Model Diagnostics

- Model fits to survey indices-at-age



Adapted from Figures 57-59

Model Results

- Model results
  - 2015 update results are consistent with the 2014 update results
  - SSB_{2015}
    - M=0.2: 2,225 mt
    - M-ramp: 2,536 mt
  - F_{2015}
    - M=0.2: 0.956
    - M-ramp: 0.932
  - Recruitment
    - Continues to be poor under both models

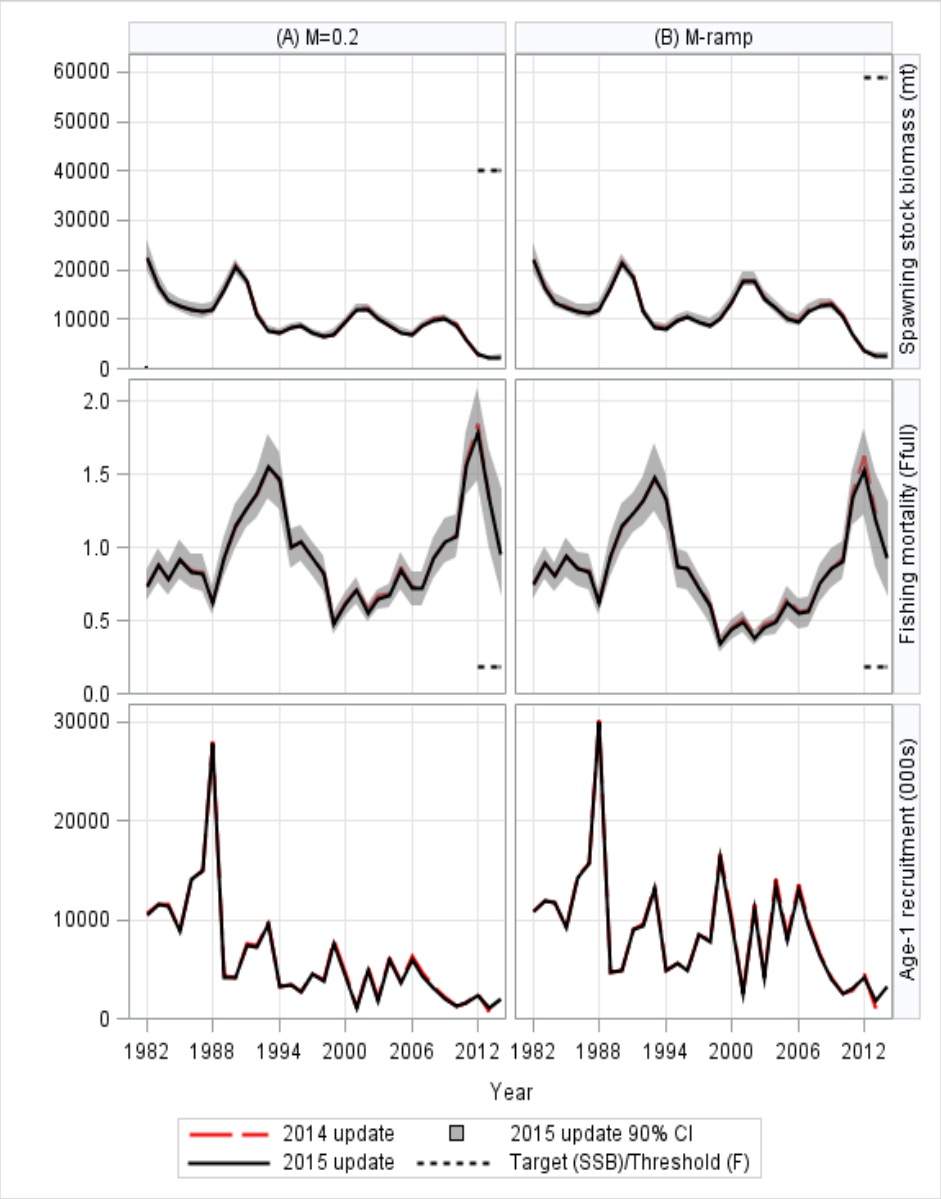
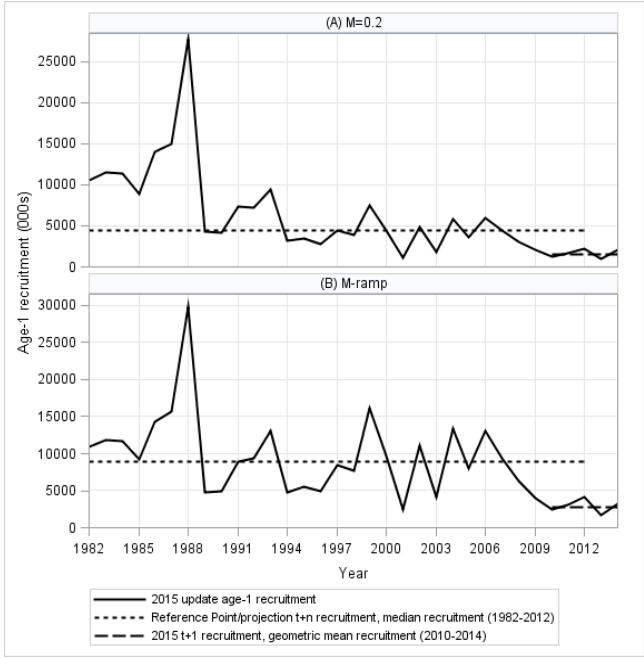
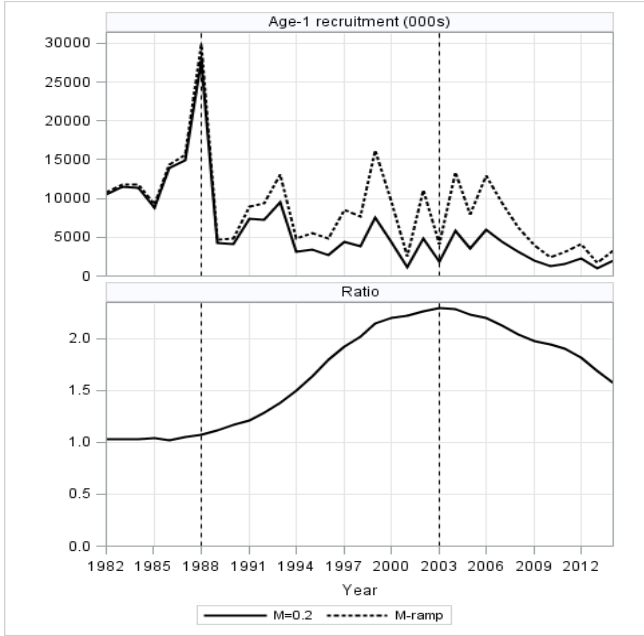


Figure 62

Model Results

- Recruitment (000s fish)
  - M=0.2
    - 1982-2012 median: 4,406
    - 2010-2014 geomean: 1,581
  - M-ramp
    - 1982-2012 median: 8,965
    - 2010-2014 geomean: 2,809
  - Differences in scale between two models is primarily a function of the increase in natural mortality between 1989 and 2014

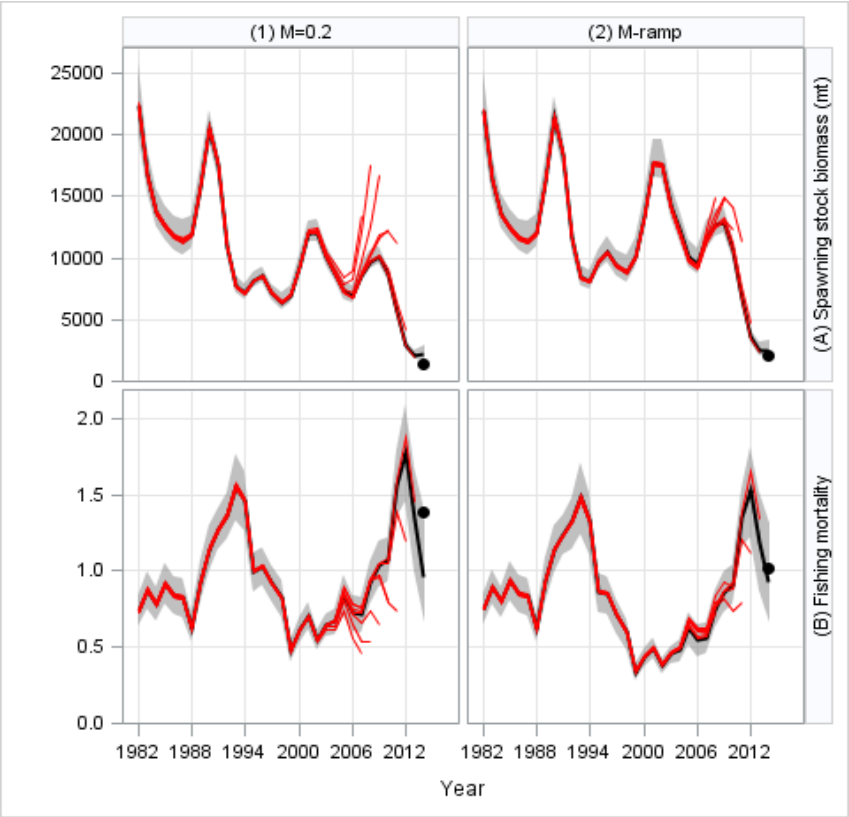


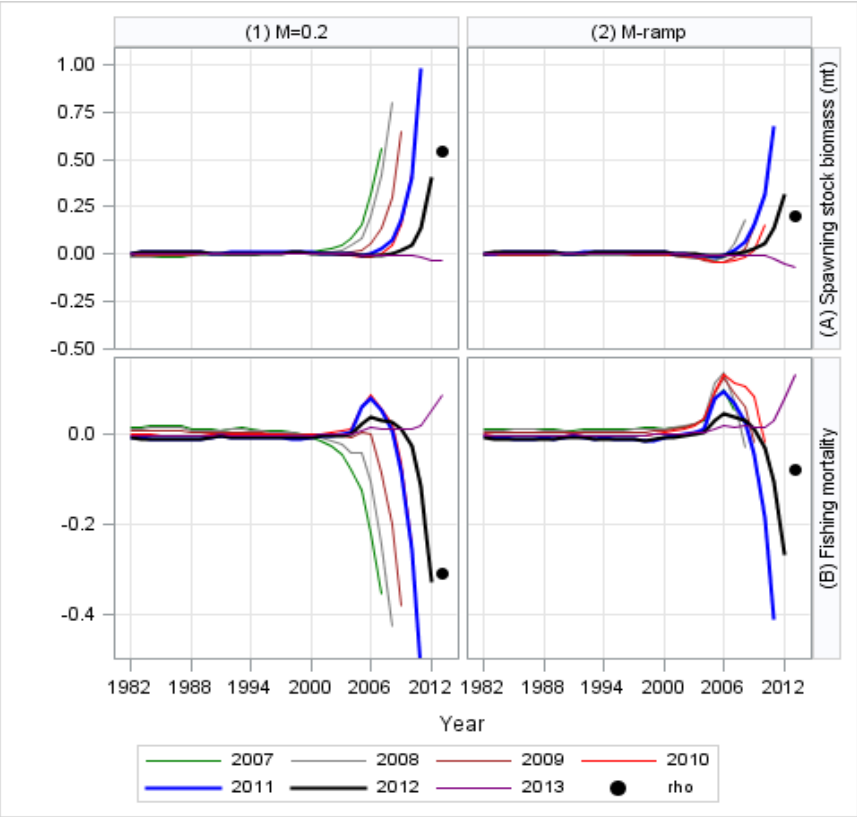


Figures 66, 67

Model Results

- Retrospective error
  - Mohn's rho:
    - SSB: M=0.2 (0.54), M-ramp (0.20)
    - F: M=0.2 (-0.31), M-ramp (-0.08)





Figures 68, 69

Model Results

- Retrospective error
  - M=0.2: major retrospective error
  - M-ramp: minor retrospective error
- Similar results to the 2014 update – no retrospective adjustment made for the M=0.2 model.

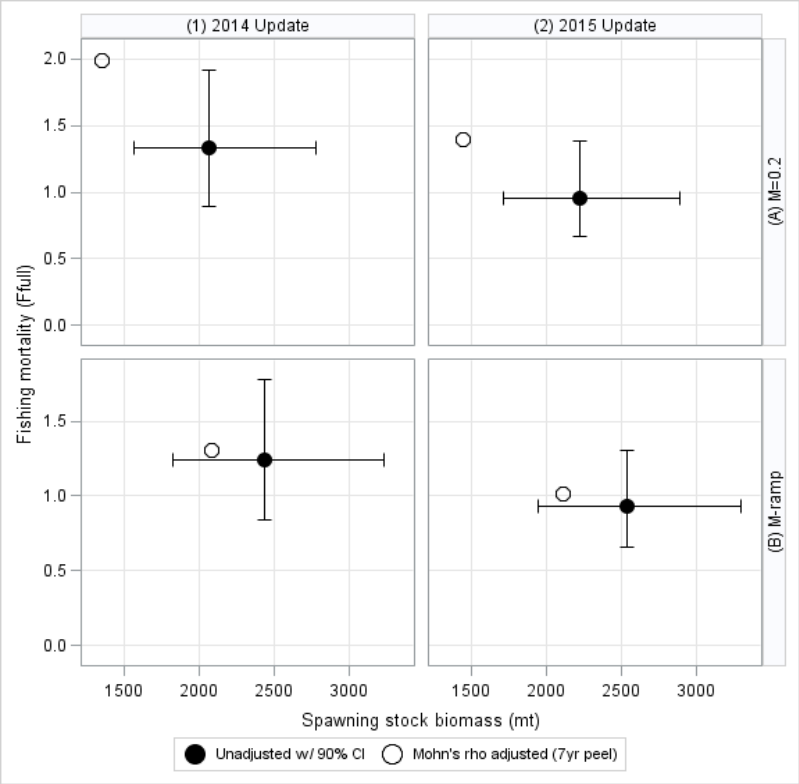


Figure 70

Biological Reference Points

- Update $F_{40\%}$ F_{MSY} proxies
  - Natural mortality assumed equal to 0.2
  - Time series average maturity ogive
  - 3-year average of weights (2012-2014)
  - Last selectivity block (2004-2014)

Age	Natural mortality	Fraction mature	Jan1/SSB weights (kg)	Mid-year weights (kg)	Catch weights (kg)	Fishery selectivity (M = 0.2)	Fishery selectivity (M-ramp)
1	0.200	0.084	0.104	0.354	0.378	0.007	0.005
2	0.200	0.292	0.522	0.814	1.094	0.041	0.032
3	0.200	0.649	1.079	1.555	1.933	0.213	0.188
4	0.200	0.893	1.854	2.120	2.479	0.628	0.615
5	0.200	0.974	2.547	2.765	2.993	0.913	0.917
6	0.200	0.994	3.392	3.638	3.754	0.985	0.987
7	0.200	0.999	4.307	4.640	4.742	0.998	0.998
8	0.200	1.000	5.702	6.280	6.281	1.000	1.000
9^+	0.200	1.000	9.866	9.866	9.866	1.000	1.000

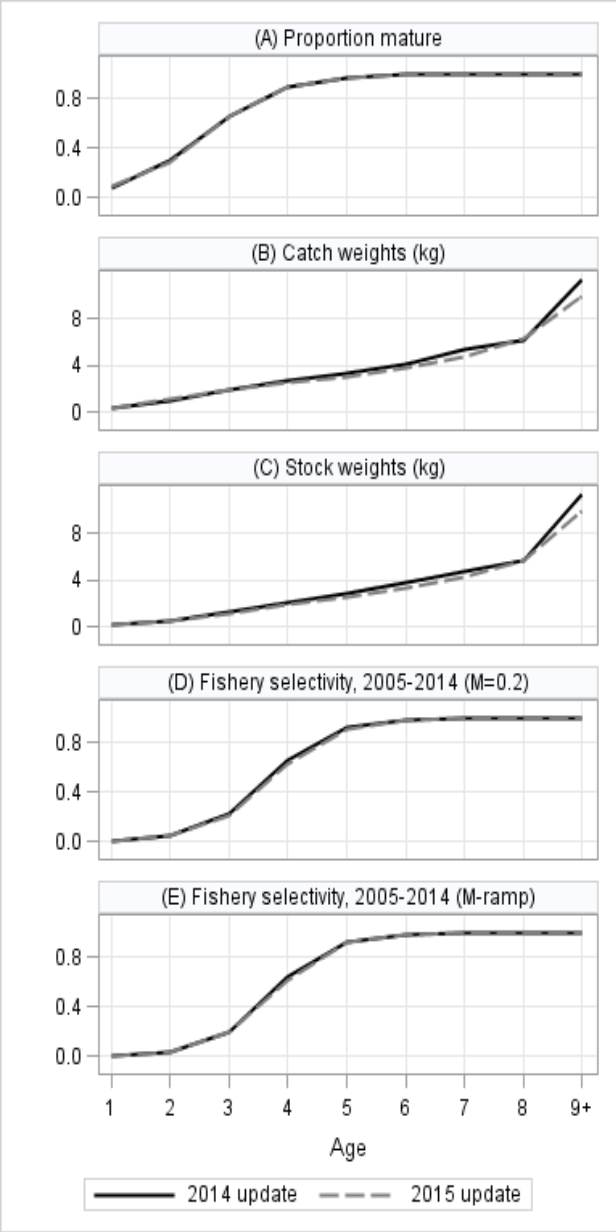


Table 38, Figure 72

Biological Reference Points

- Update SSB_{MSY} proxies
  - Based on 100 year projections run at the F_{MSY} proxy
  - Projection model samples from CDF of recruitment from 1982-2012
    - When SSB drops below a hinge point recruitment declines linearly to zero
      - M=0.2: 6,300 mt, M-ramp: 7,900 mt

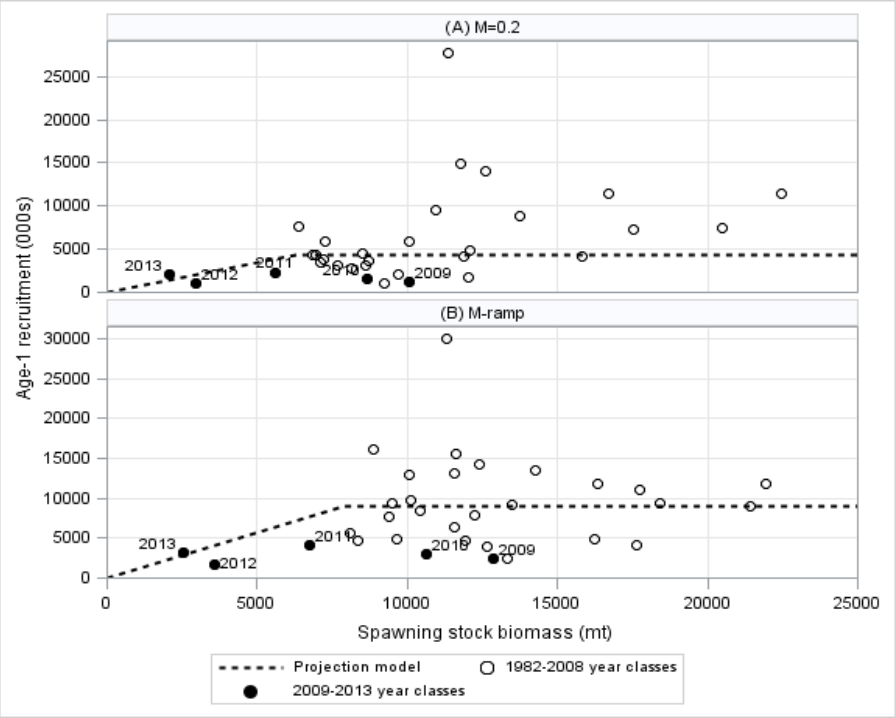


Figure 73

Stock Status

- Updated reference points and stock status
  - Overfished and overfishing is occurring

Assessment	Proxy reference points	M=0.2	M-ramp
2015 update	$F_{full,\ 2014}$	0.956 (0.664 - 1.387)	0.932 (0.654 - 1.304)
	F_{MSY}	0.185	0.187
	$F_{full,\ 2014}/F_{MSY}$	5.11	4.98
	Overfishing	Yes	Yes
	SSB_{2014} (mt)	2,225 (1,713 - 2,892)	2,536 (1,942 - 3,298)
	SSB_{MSY} (mt)	40,187 (27,551 - 58,228)	59,045 (44,976 - 76,525)
	SSB_{2014}/SSB_{MSY}	0.06	0.04
	Overfished	Yes	Yes
	MSY (mt)	6,797 (4,608 - 9,990)	10,043 (7,560 - 13,130)
	Median age1 recruitment (000s)	4,406 (1,458 - 14,450)	8,965 (2,489 - 15,908)

Adapted from Table 40

Short-term Projections

- Updated short-term projections (2016-2018)
  - M=0.2: base projection and retro-adjusted projection
  - M-ramp: Two assumptions of natural mortality in the short-term
    - M=0.2 or M=0.4

  - All projections run at both F_{MSY} or 75% F_{MSY}
    - Assumed catch of 279 mt in 2015 (*GARFO*)

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}	2014	Model result	1,471	2,225	0.956	1,471	1,443	1.390	1,471	2,536	0.932	1,471	2,536	0.932
	2015	Assumed catch	279	3,045	0.111	279	1,961	0.174	279	3,219	0.112	279	3,057	0.123
	2016	Projection	697	4,400	0.185	438	2,777	0.185	748	4,950	0.187	555	3,841	0.187
	2017	Projection	939	5,852	0.185	596	3,723	0.185	1,085	7,062	0.187	662	4,536	0.187
	2018	Projection	1,211	7,601	0.185	773	4,854	0.185	1,507	9,674	0.187	765	5,220	0.187
75% F_{MSY}	2014	Model result	1,471	2,225	0.956	1,471	1,443	1.390	1,471	2,536	0.932	1,471	2,536	0.932
	2015	Assumed catch	279	3,045	0.111	279	1,961	0.174	279	3,219	0.112	279	3,057	0.123
	2016	Projection	533	4,435	0.139	335	2,800	0.139	570	4,988	0.140	423	3,871	0.140
	2017	Projection	738	6,048	0.139	468	3,848	0.139	847	7,278	0.140	517	4,672	0.140
	2018	Projection	974	8,015	0.139	621	5,113	0.139	1,201	10,141	0.140	609	5,464	0.140

Table 41

Summary

- Fishery and survey data continue to show few large/old fish, indicating total mortality remains high

- Overall survey indices and percent occurrence remains low

- Model results are similar to the 2014 assessment update
  - SSB: 2,225/2,536 mt
  - F: 0.956/0.932
  - Recruitment continues to be poor

- Biological reference points are lower than 2014 assessment
  - Reflect continued poor recruitment

- Stock remains overfished and overfishing is occurring

Figure 48

Questions?