Bristol Bay Red King Crab Assessment in Fall 2018

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Outline

5. Projections and future outlook

4. Alternative baselines for B35% and ABC setting

3. Assessment results

2. New data and model scenarios

1. Responses to CPT and SSC Review Comments

Response to CPT Comments

Response to CPT Comments (from September 2017):

"Look at the weighting again for this assessment: it is still based on multiplicative lambda's."

Response: Corresponding CV values are provided for the lambda values in this SAFE report.

"The difficulties achieving convergence need to be explored: they are unexpected and concerning."
"Jittering initial parameter values was not used in this assessment, but may be useful in evaluating convergence issues."

Response: for convergence, it is a concern. At the September 2017 CPT meeting, Jack Turnock mentioned that he had similar problems with the snow crab model. This could be parameter confounding or initial value problems.

We used jittering before and may use it in the future.

Response to CPT Comments

Response to CPT Comments (from September 2017):

"The tensions in the assessment data leading to estimates of NMFS survey Q at 1 need to be identified and approaches to deal with them need to be developed."

Response: This could be caused by a few reasons: (1) The error of underweighting BSFRF survey biomass, (2) M and Q are confounded, (3) the sharp decline of abundance in the early 1980s may make estimated Q higher. We did several scenarios in May 2018 to explore Q values. After correcting the error, estimated Q value is 0.91 with scenario 2b in this report.

"The assessment document needs to be updated to reflect changes in the 2016 BSFRF estimate in the main section of text, not just in the Executive Summary."

Response: This was done in 2017 SAFE report.

"Provide an explanation of why Equation A4 (catch in the directed fishery) is correct (or correct it if it is wrong)."

Response: The equation A4 is correct. It is a simple equation under the assumption of pulse fishing. Total abundance is reduced by natural mortality to the mid-point of the directed pot fishing and then total fishing mortality is applied to the remaining abundance to get catch. For females, it is female bycatch. For males, the retained catch and bycatch are then separated by their selectivity proportions. The Tanner crab fishery and groundfish fisheries are assumed to be pulse fishing and occur after the directed fishery.

Response to CPT Comments

Response to CPT Comments (from May 2018):

"1) fitting the total catch estimated from at-sea observer data and total retained catch without incorporating the "subtraction" method for estimating legal discards,"

Response: Done for scenarios 18.0, 18.0a, 18.0b and 18.0c.

"2) incorporating time varying fishery selectivity and annual retained proportions,"

Response: Scenarios 18.0, 18.0b and 18.0c address this.

"3) the recruitment in terminal year should not be used for estimating B35% (i.e., mean recruitment is estimated from recruitments from 1984 to endyear – 1)."

Response: Scenarios 18.0, 18.0b and 18.0c address this.

Response to SSC Comments

Response to SSC Comments specific to this assessment (from Oct. 2017):

"The SSC reiterates its request from June 2017 for the BBRKC author and CPT to objectively define the terminal year of recruitment to include in reference point calculations in this and other crab assessments, and again requests that the author use the breakpoint analysis applied for Tanner crab to BBRKC to evaluate whether there was a detectable break in production in 2006. The SSC looks forward to the outcomes of a more comprehensive discussion on this topic at the January 2018 CPT meeting."

Response: Analysis of terminal year of recruitment is included in this draft SAFE report. Based on the results, we recommend not including the recruitment in the most recent year. Breakpoint analysis was done in May 2017, which includes brood years only up to 2005. We will repeat the breakpoint analysis in May 2019 to detect brood year 2006 when we get one more data point.

"This assessment uses the number of lengths measured as a starting point for input sample sizes. The SSC recommends following the approach of other crab and groundfish stocks in using the number of stations or pots sampled as a better proxy for statistical sample size given the frequently very high correlation among individuals within a single sample."

Response: The Bristol Bay red king crab model includes length composition data from the trawl survey, directed pot fishery, Tanner crab fishery bycatch, groundfish trawl bycatch, and groundfish fixed gear bycatch. It is difficult to find measurement units of sample sizes that are comparable. The number of survey hauls will be almost constant over time, which is difficult to compare with number of pots, or boat-days, or trips. Snow and Tanner crab models have the same problem. Hopefully we can learn from the groundfish stock model approaches and find a better way to deal with sample sizes in the future.

Response to SSC Comments

Response to SSC Comments specific to this assessment (from Oct. 2017):

"*More research on catchability is needed, including review of existing camera work from BSFRF surveys that may shed light on crab behavior in response to trawl gear. The SSC provided some comments on new research using modifications of the BSFRF Model under the subsection "Crab Bycatch" earlier in this report.*"

Response: We agree with these suggestions for needed research. Analysis of camera work from BSFRF surveys will be helpful, especially on the herding effects of BSFRF surveys.

"The CPT suggested that large catches that drove the stock down in the early 1980s could drive the fits, resulting in an estimate of q near 1.0. On this basis, other evaluation of q could include investigating the effect of the period of historical decline (perhaps by down-weighting it) on more recent estimates of catchability, or fitting a research model fit to BBRKC with only data after the stock collapse in the early 1980s."

"The SSC noted that historical modelling was conducted using relatively simple catch-survey analysis (Collie and Kruse 1998; Can. Spec. Publ. Fish. Aquat. Sci. 125: 73-83). This might provide another tool for exploring why current estimates of catchability are so close to 1.0."

Response: See the response above on CPT comments. The catch-survey analysis (Collie and Kruse 1998; Can. Spec. Publ. Fish. Aquat. Sci. 125: 73-83) is a simple way to explore Q and M relationships. With similar M values as our model, Q is estimated to be 0.95 by Collie and Kruse (1998); however, with a constant M of 0.36, Q is estimated to be 1.01.

Response to SSC Comments

Response to SSC Comments specific to this assessment (from June 2018):

"to not use the subtraction method moving forward."

Response: Agree and no subtraction method from now on.

"The SSC also requests that the authors investigate whether groundfish discard information is available for fixed gear prior to 2010. In addition, the document uses inconsistent terminology for pot gear and fixed gear (particularly on figure and table headings), as well as groundfish gear versus crab gear, and the associated mortality rates. The SSC requests that the authors check the document for consistent use of these terms."

Response: We did some preliminary search on groundfish bycatch data and found that the data from 1991 to 2009 have been added to the NMFS database. During these years, fixed gear bycatch is an average of 22.6% of total groundfish bycatch. Due to time constraint, we will not separate groundfish bycatch into trawl and fixed gear bycatch before 2009 for this CPT meeting (September 2018) and will sort out these data and use them in the CPT meeting in May 2019.

We went through our SAFE report to check for consistent use of gear terms and corrected them as necessary.

Summary of Major Changes in 2018

1. Changes to the input data:
   a. The new 2018 NMFS trawl survey data.
   b. Catch and bycatch data were updated through 2018.

Summary of Major Changes in 2018

2. Changes to the assessment methodology:

a. Correcting two coding errors that result in overweighting small size length composition data of NMFS surveys and underweighting BSFRF survey biomass. These two errors were discovered recently by Dr. Andre Punt while working on GMACS. Combinations of these two errors make the model fit the NMFS survey data a little better and fit the BSFRF data a little worse. Comparison of the model results with the errors and without the errors are showed in survey biomass fits and absolute mature male biomass. The two errors do not affect past TACs and fishery.

b. Estimated recruitment in the terminal year is not used for estimating B35%. That is, the mean recruitment from 1984-2017 is used for estimating B35%.

c. For the directed pot fishery, the model fits total observer male biomass and length compositions, instead of discarded male biomass and length compositions.

d. Analyses of terminal year of recruitment and dynamic B0 (see Appendix C).

e. Six Model Scenarios

2b. The scenario 2b in the SAFE report in September 2017 with correction of the two errors mentioned in (a) above.

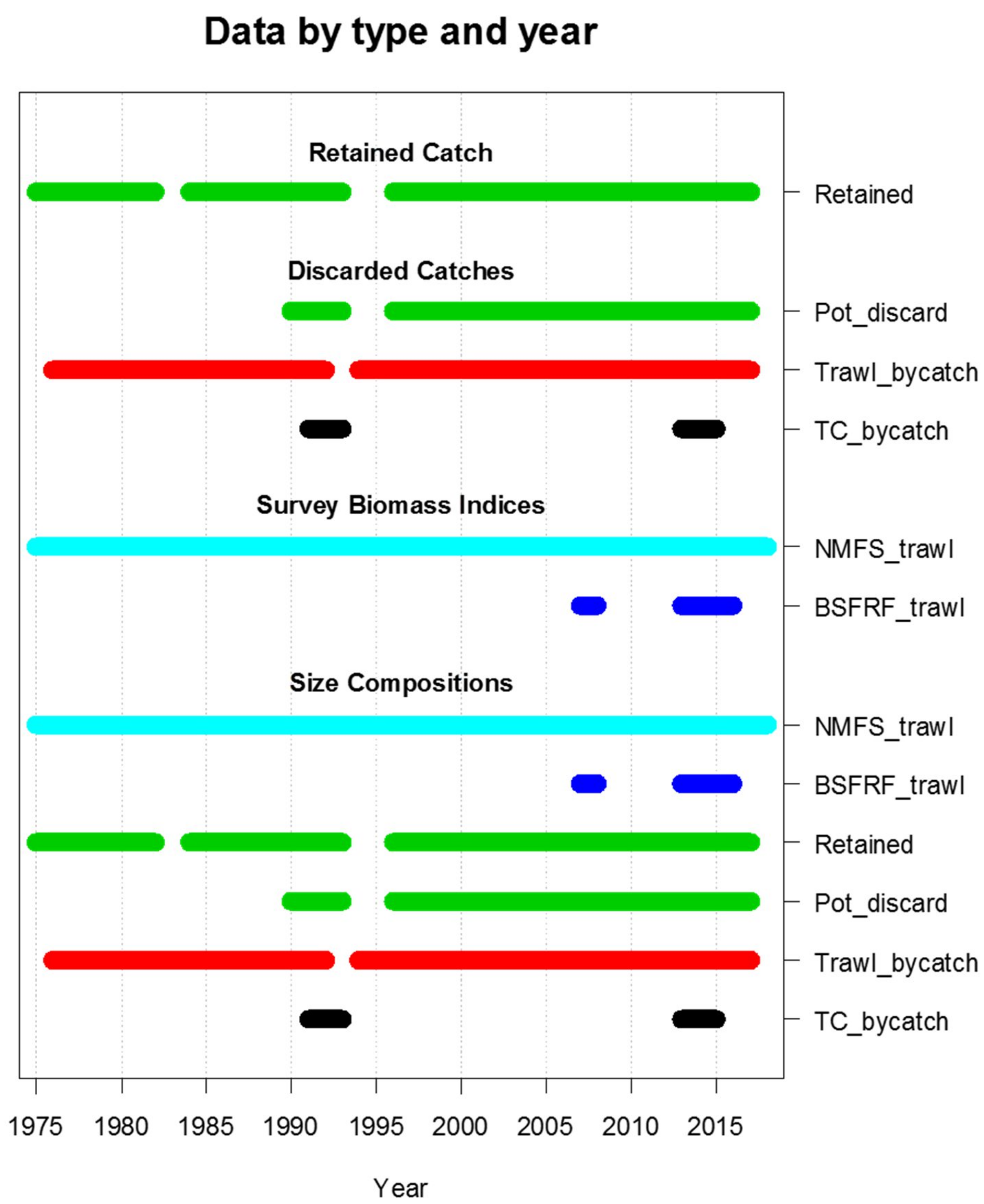
2b-old. The scenario 2b in the SAFE report in September 2017 without two error corrections. The purpose to include this scenario is to compare it with scenario 2b to examine the impacts of the two errors on the results.

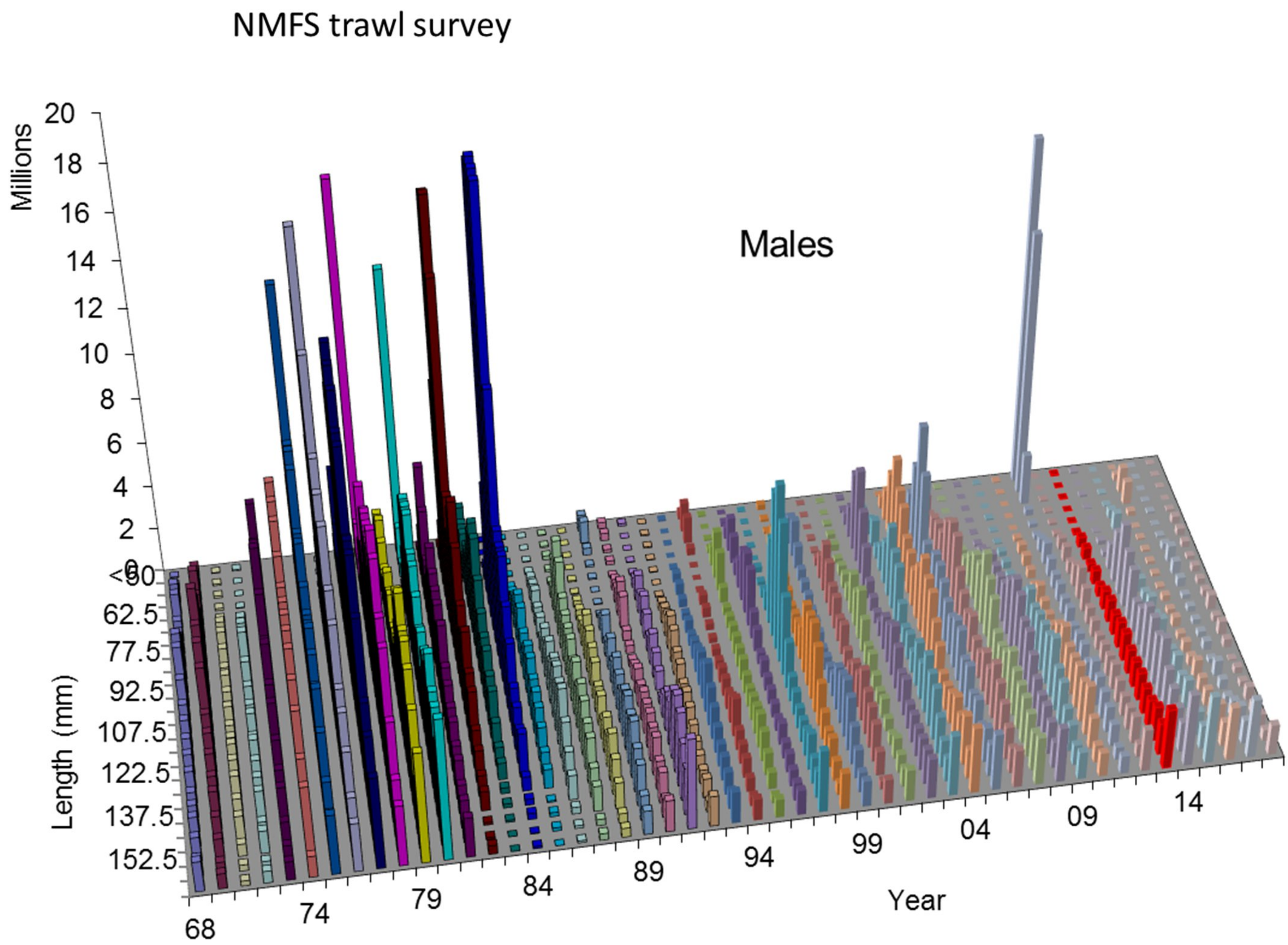
18.0. Renamed from scenario 2bn1 in May 2018 with some changes based on the requests of CPT and SSC: using total observer male biomass and total observer male length composition data in the directed pot fishery.

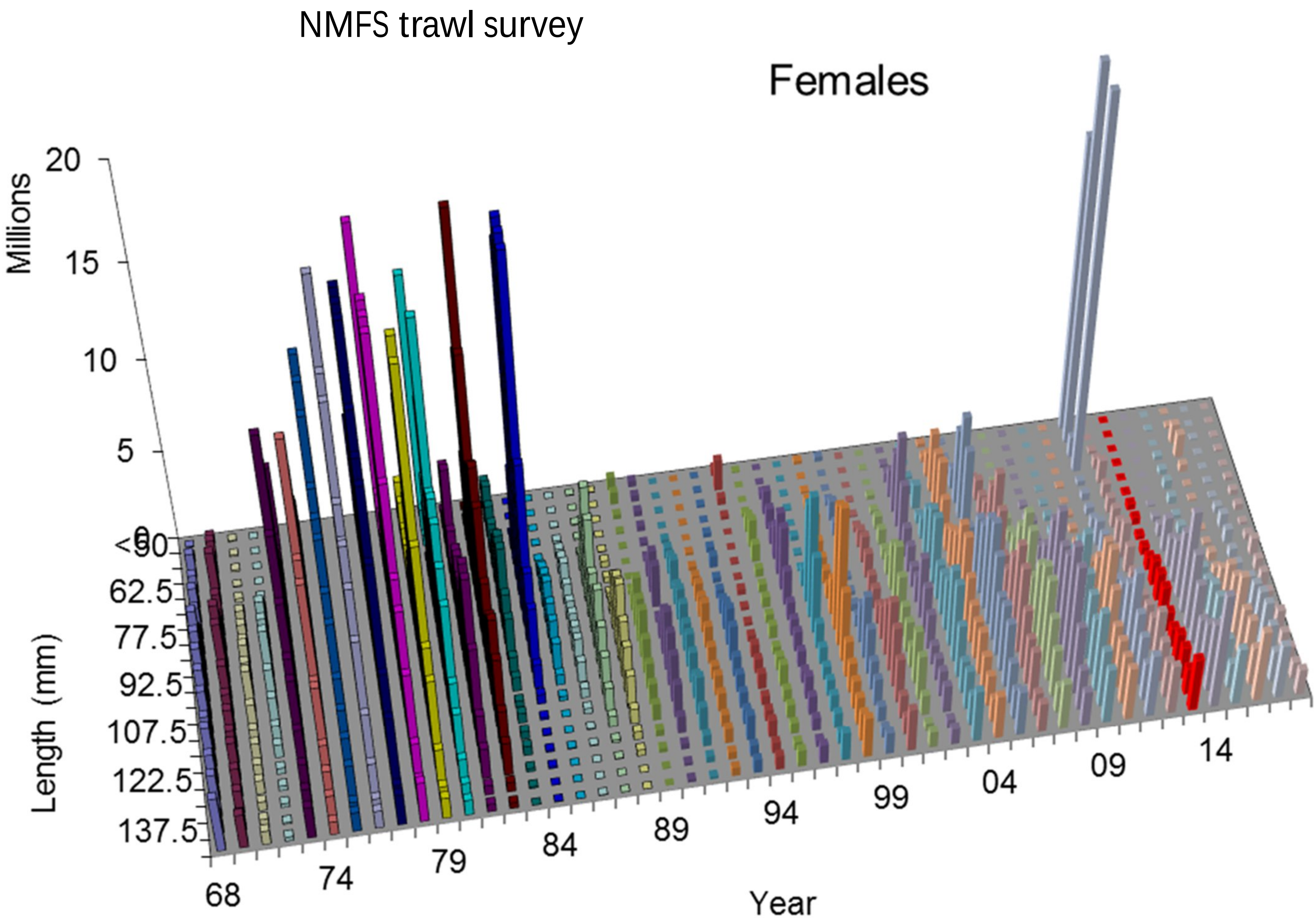
18.0a. The same as scenario 18.0 except with equal annual effective sample sizes of male and female length compositions.

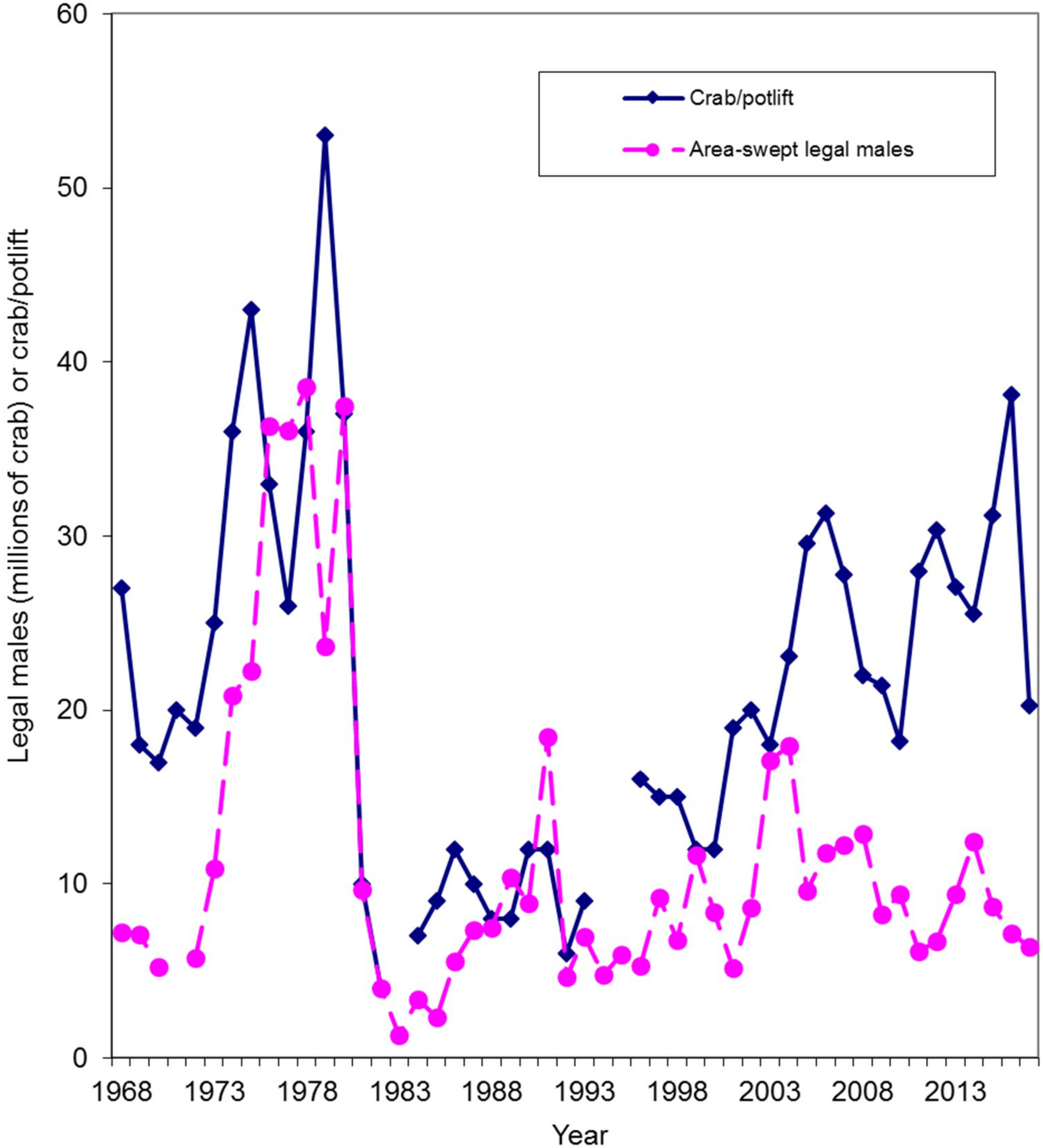
18.0b. Renamed from scenario 2bn2 in May 2018 with some changes based on the requests of CPT and SSC and the same as scenario 18.0 except that only one logistic curve is estimated for all years for retained proportions and annual retention adjusted factors are estimated to modify retained proportions for years after 2004.

18.0c. The same as scenario 18.0 except with the differences of total male selectivity and retained proportions in the directed pot fishery: (1) one logistic curve for total male selectivity is estimated with annual deviations of length at 50% selectivity parameter(?$^{? ??,?? ?}_{? ?}$) and (2) another logistic curve is estimated for all years for retained proportions and for years after 2004 with annual deviations of length at 50% retained proportion parameter (?$^{???}_{??}$).

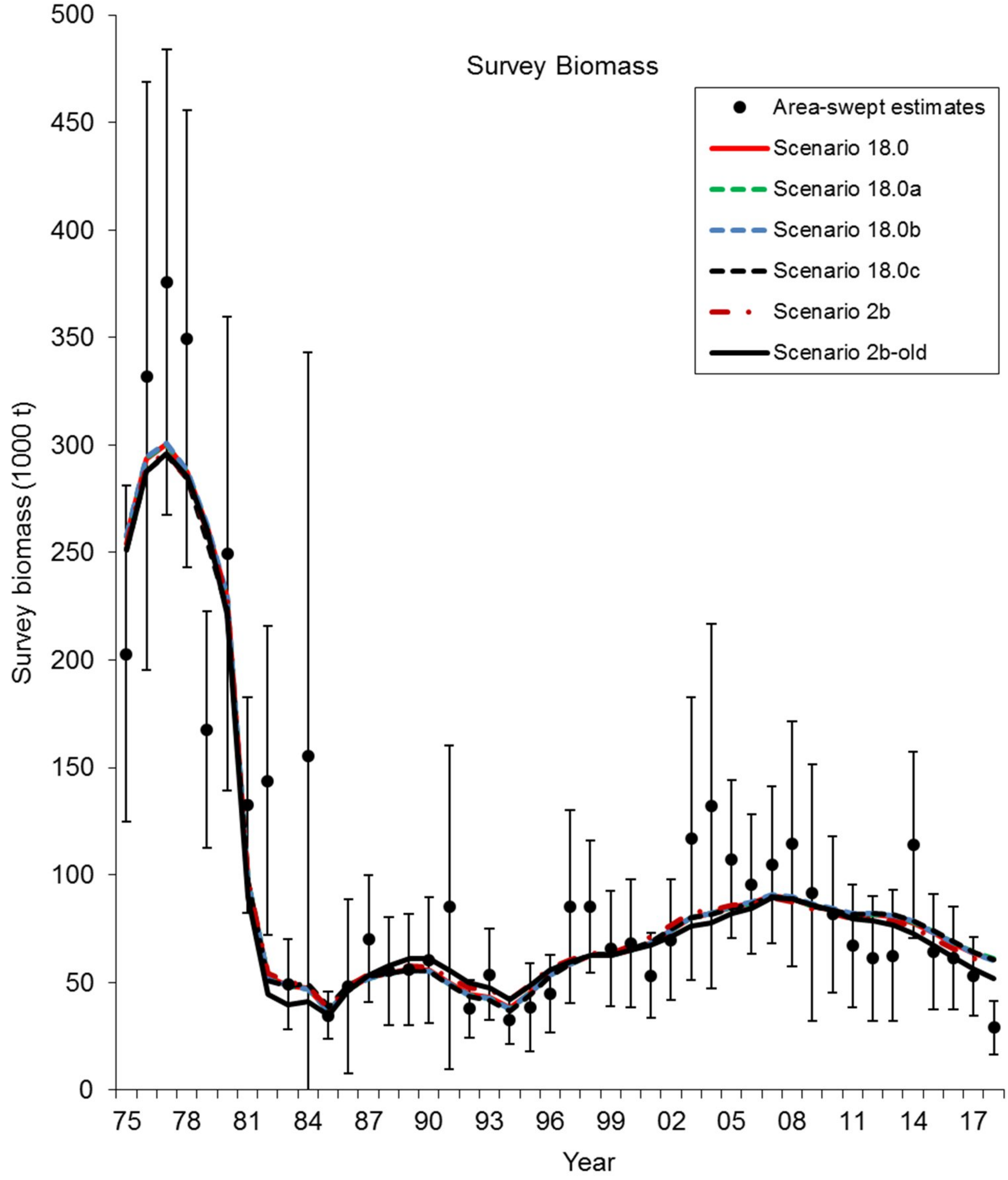

Data by type and year
Retained Catch
Retained
Discarded Catches
Pot_discard
Trawl_bycatch
TC_bycatch
Survey Biomass Indices
NMFS_trawl
BSFRF_trawl
Size Compositions
NMFS_trawl
BSFRF_trawl
Retained
Pot_discard
Trawl_bycatch
TC_bycatch
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year


NMFS trawl survey
Males
Millions
20
18
16
14
12
10
8
6
4
2
0
<50
62.5
77.5
92.5
107.5
122.5
137.5
152.5
Length (mm)
68
74
79
84
89
94
99
04
09
14
Year

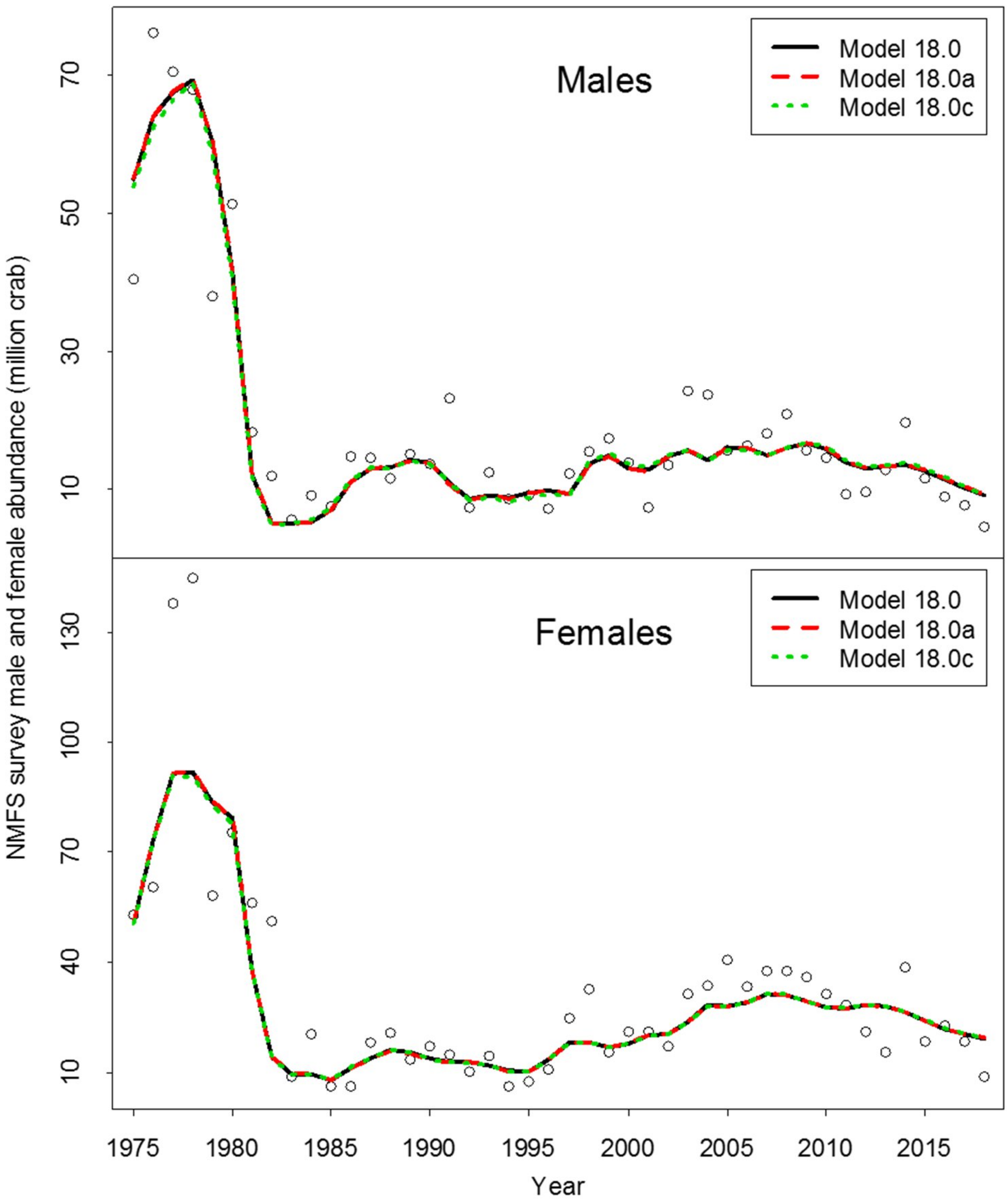

NMFS trawl survey
Females
Millions
20
15
10
5
0
<50
62.5
77.5
92.5
107.5
122.5
137.5
Length (mm)
68
74
79
84
89
94
99
04
09
14
Year



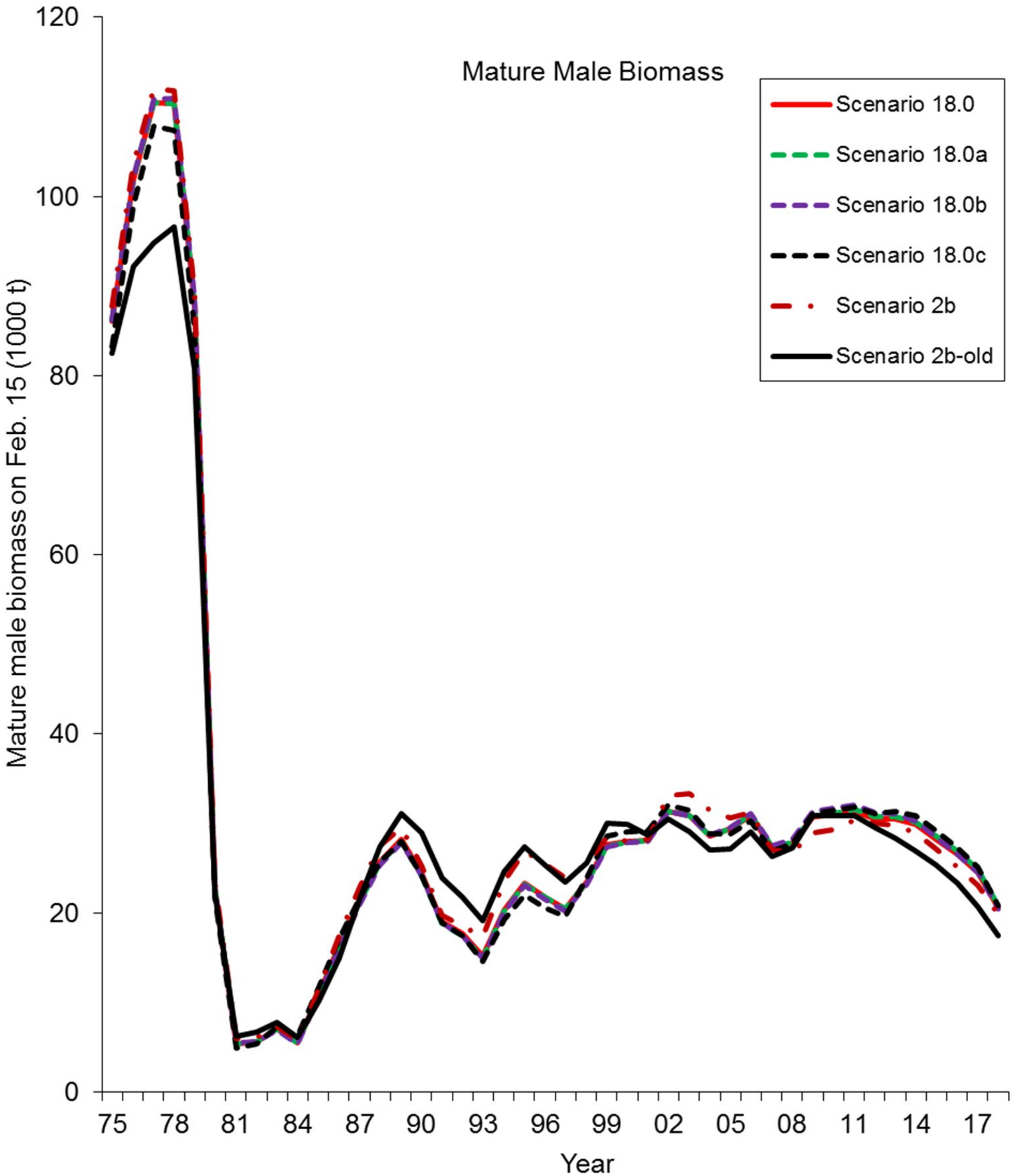
Crab/potlift
Area-swept legal males
Legal males (millions of crab) or crab/potlift
Year
0
10
20
30
40
50
60
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013



Comparisons of area-swept estimates of total NMFS survey biomass and model biomass and model prediction for model estimates in 2018 under scenarios 18.0, 18.0a, 18.0b, 18.0c, 2b and 2b-old. The error bars are plus and minus 2 standard deviations.



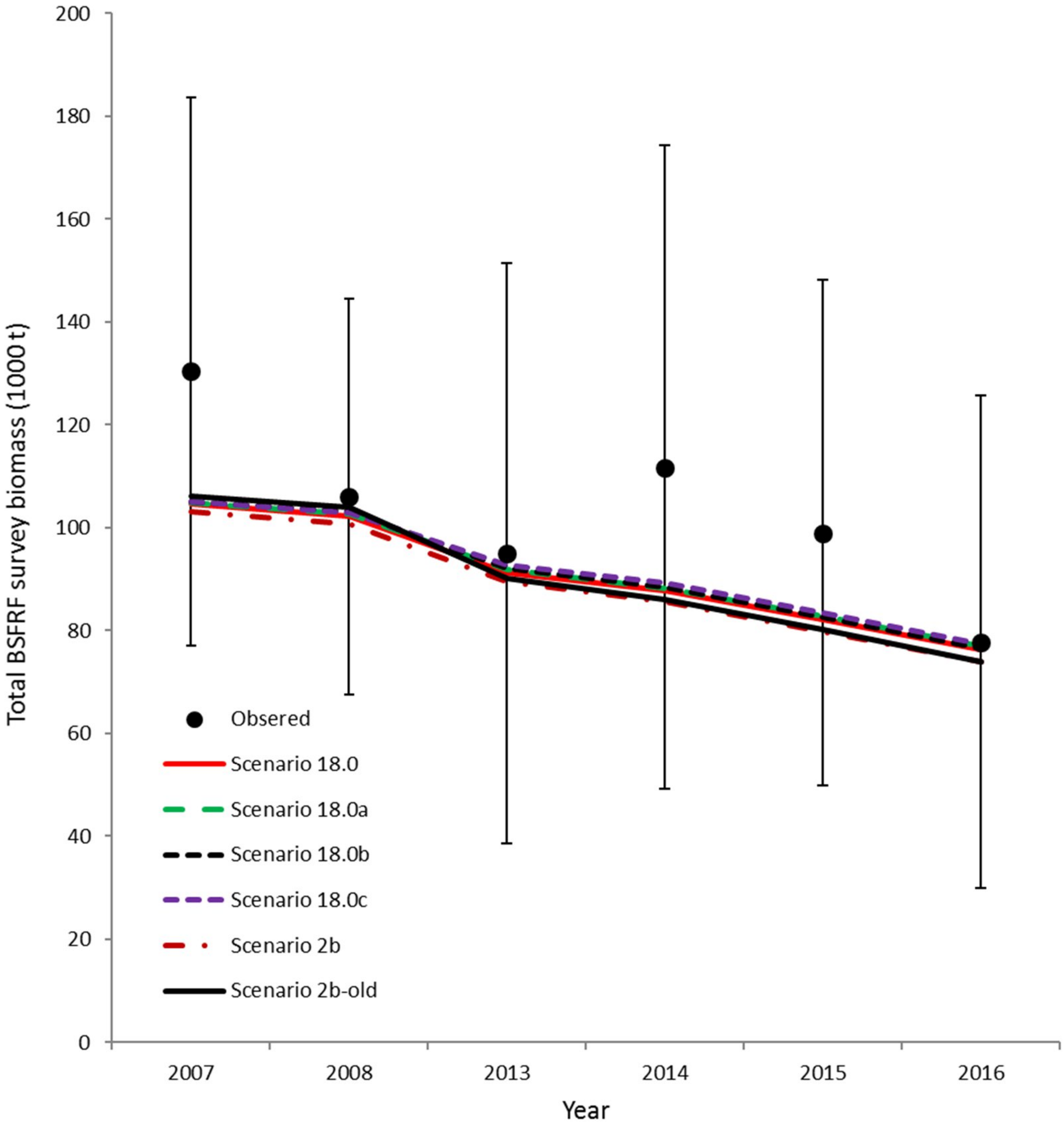
Comparisons of NMFS survey area-swept estimates of male (>119 mm) and female (>89 mm) abundance and model prediction for model estimates in 2018 under scenarios 18.0, 18.0a, and 18.0c.



Comparisons of mature male biomass on Feb. 15 under scenarios 18.0, 18.0a, 18.0b, 18.0c, 2b and 2b-old

Estimated trawl survey catchabilities:

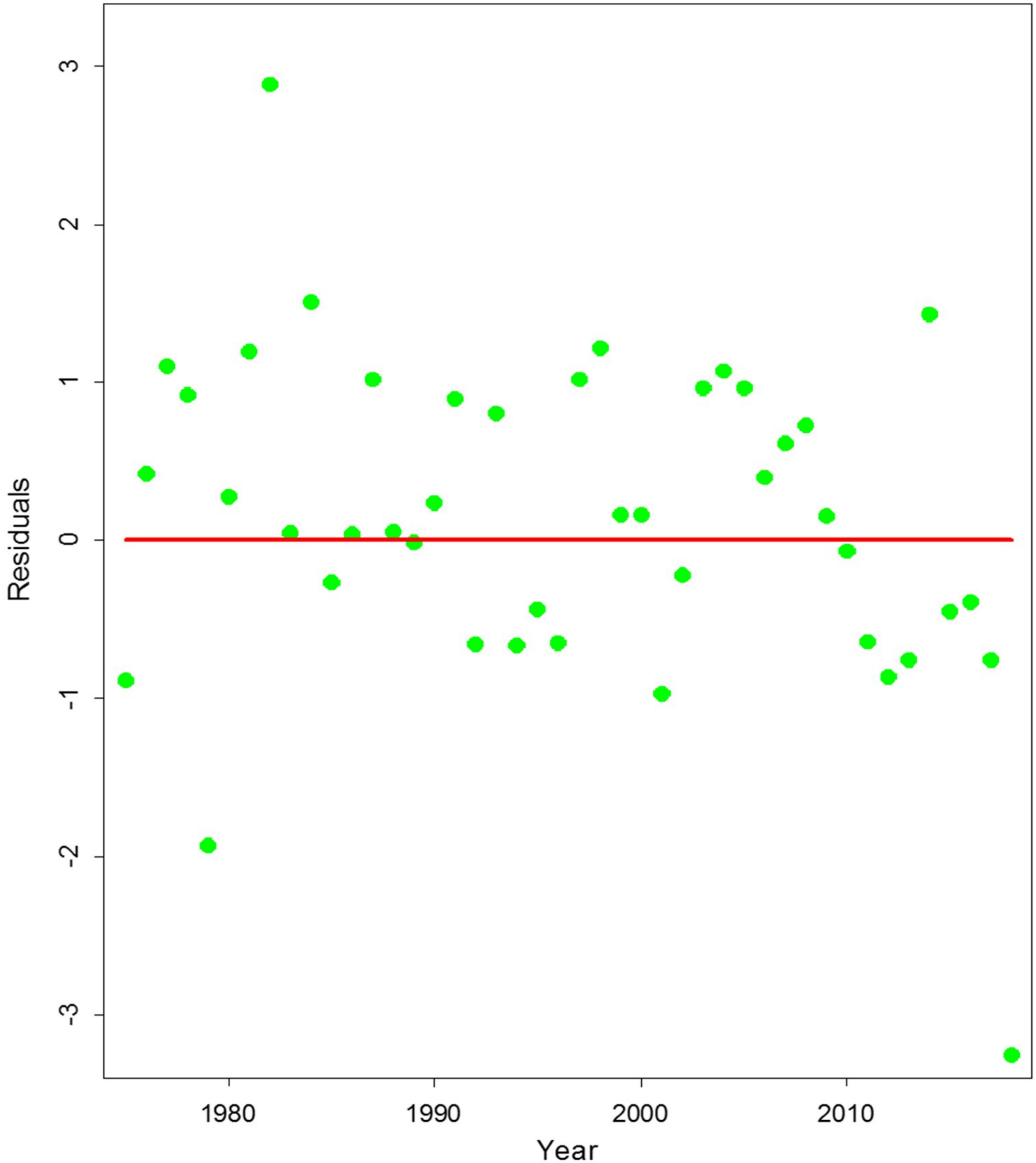
Scenario	Q
18.0	0.925
18.0a	0.925
18.0b	0.923
18.0c	0.929
2b	0.911
2b-old	0.957



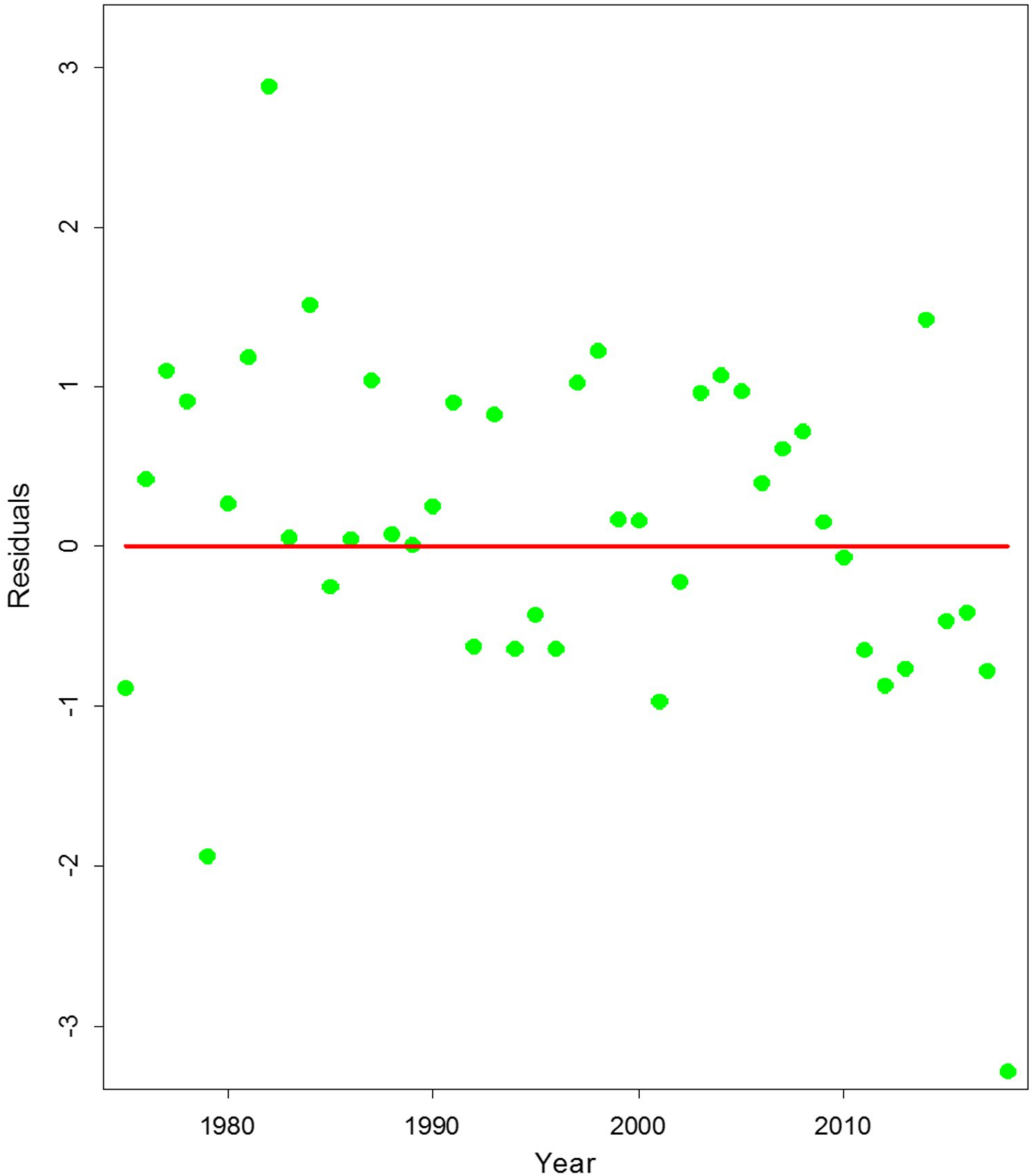
Comparisons of total survey biomass estimates by the BSFRF survey and the model for model estimates in 2018 (scenarios 18.0, 18.0a, 18.0b, 18.0c, 2b and 2b-old). The error bars are plus and minus 2 standard deviations of scenario 18.0.

Comparison of Scenarios 2b and 2b-old

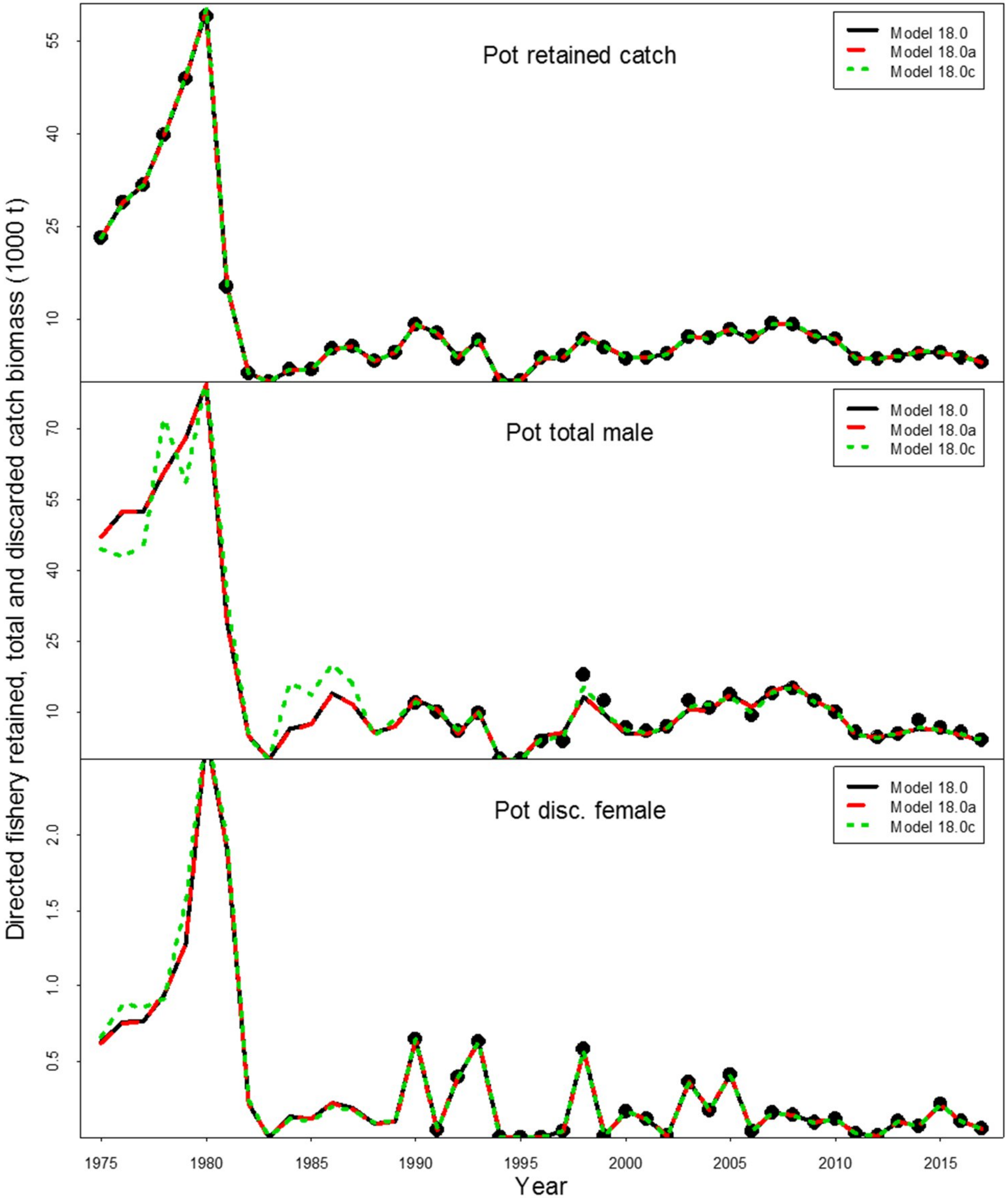
1. Model estimated relative biomasses are very similar. Because of overweighting NMFS survey small length composition data and underweighting BSFRF survey biomass, scenario 2b-old fits the NMFS survey data better than scenario 2b.
2. Model estimated absolute mature male biomass:
   a. Average relative error: -1.6%.
   b. Average absolute relative error: 7.5%.
   c. During the period covering the BSFRF survey data (2006-2017), relative errors ranging from -10.4% to 6.4%.
3. Overall the differences are relatively small.
4. The two errors do not affect past TACs and fishery.



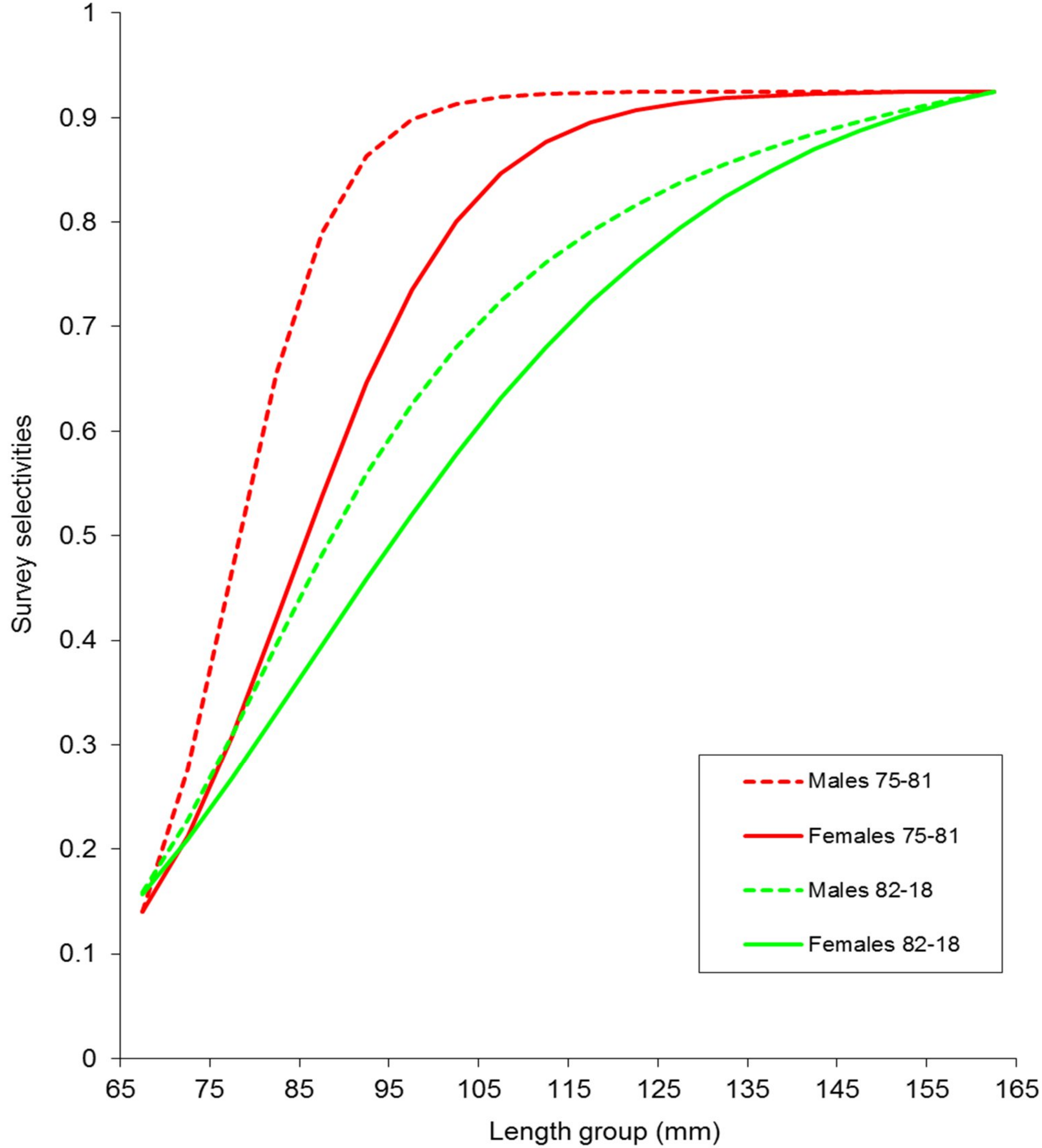
Standardized residuals of total NMFS survey biomass. Scenario 18.0



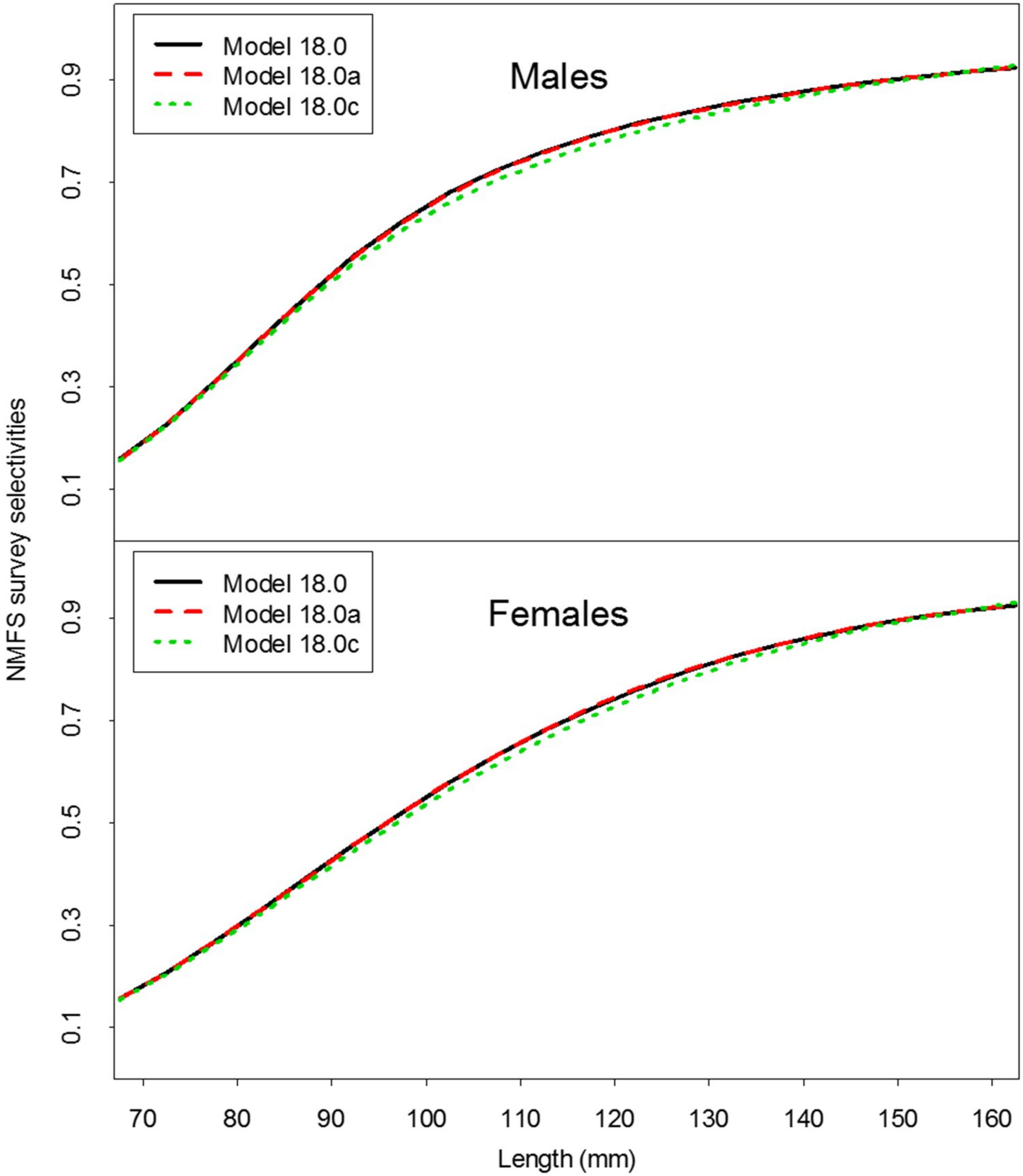
Standardized residuals of total NMFS survey biomass. Scenario 18.0a



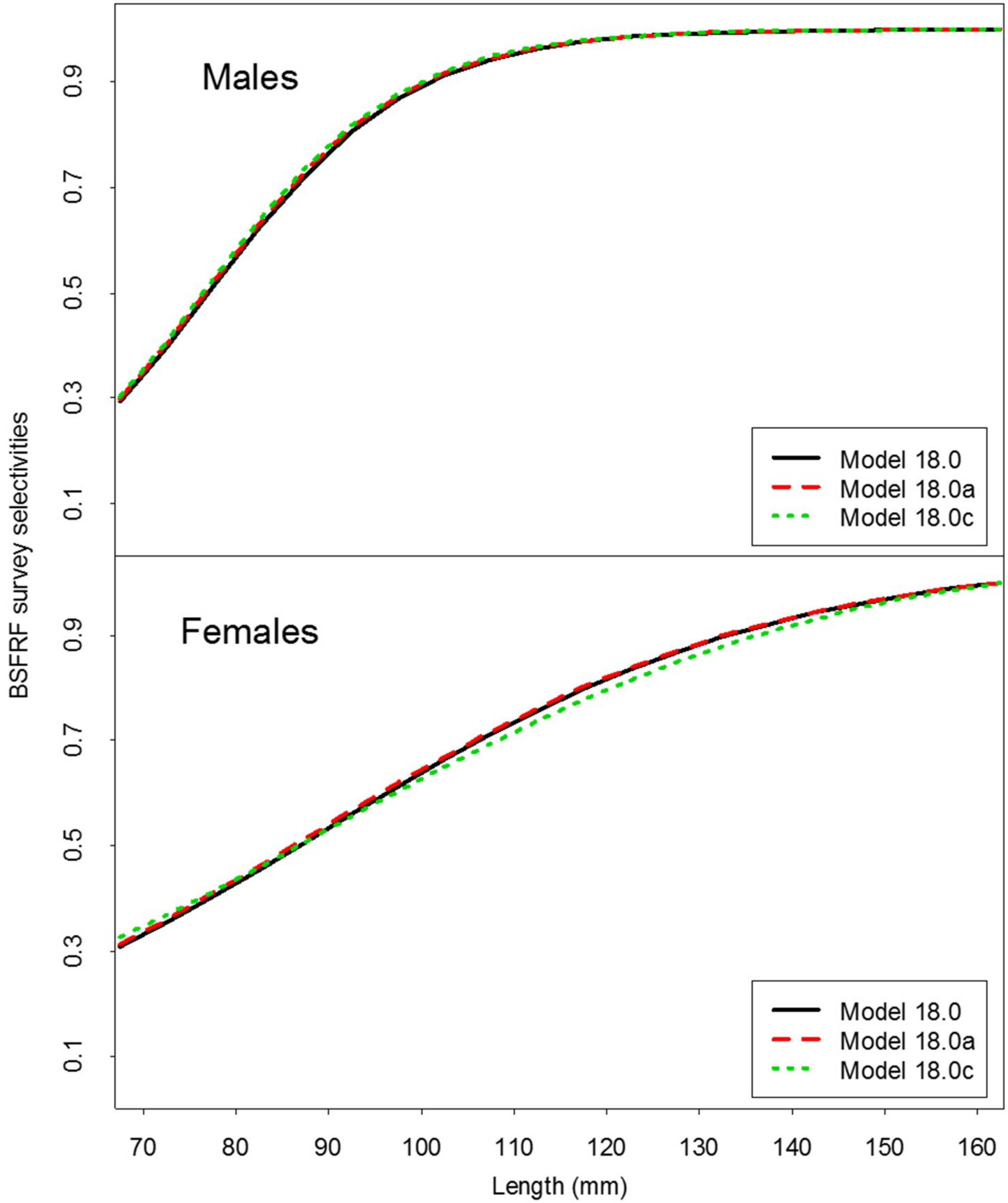
Comparisons of observed and predicted catch mortality biomass under scenarios 18.0, 18.0a, and 18.0c. Mortality biomass is equal to caught biomass times a handling mortality rate.



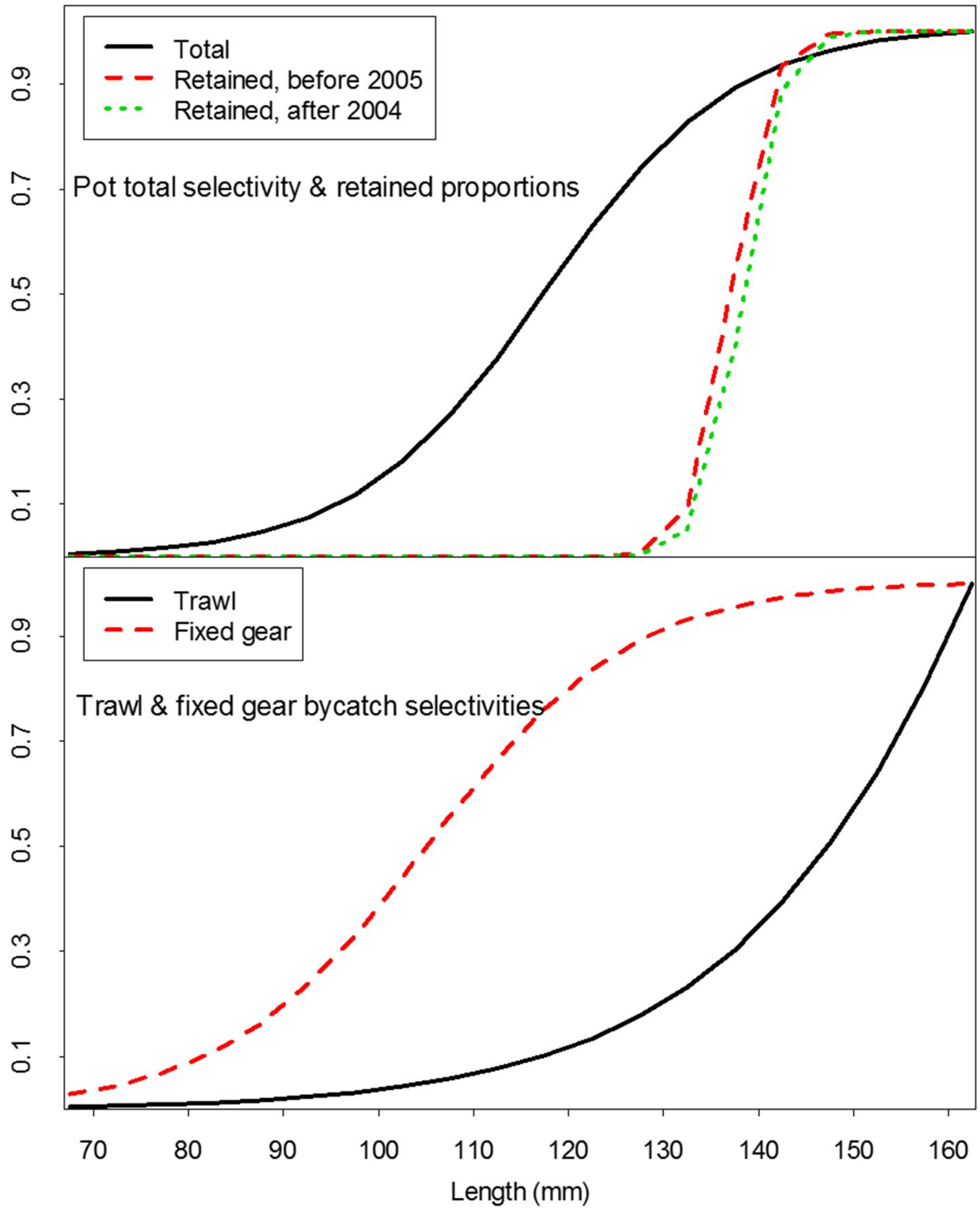
NMFS survey:
Scenario 18.0



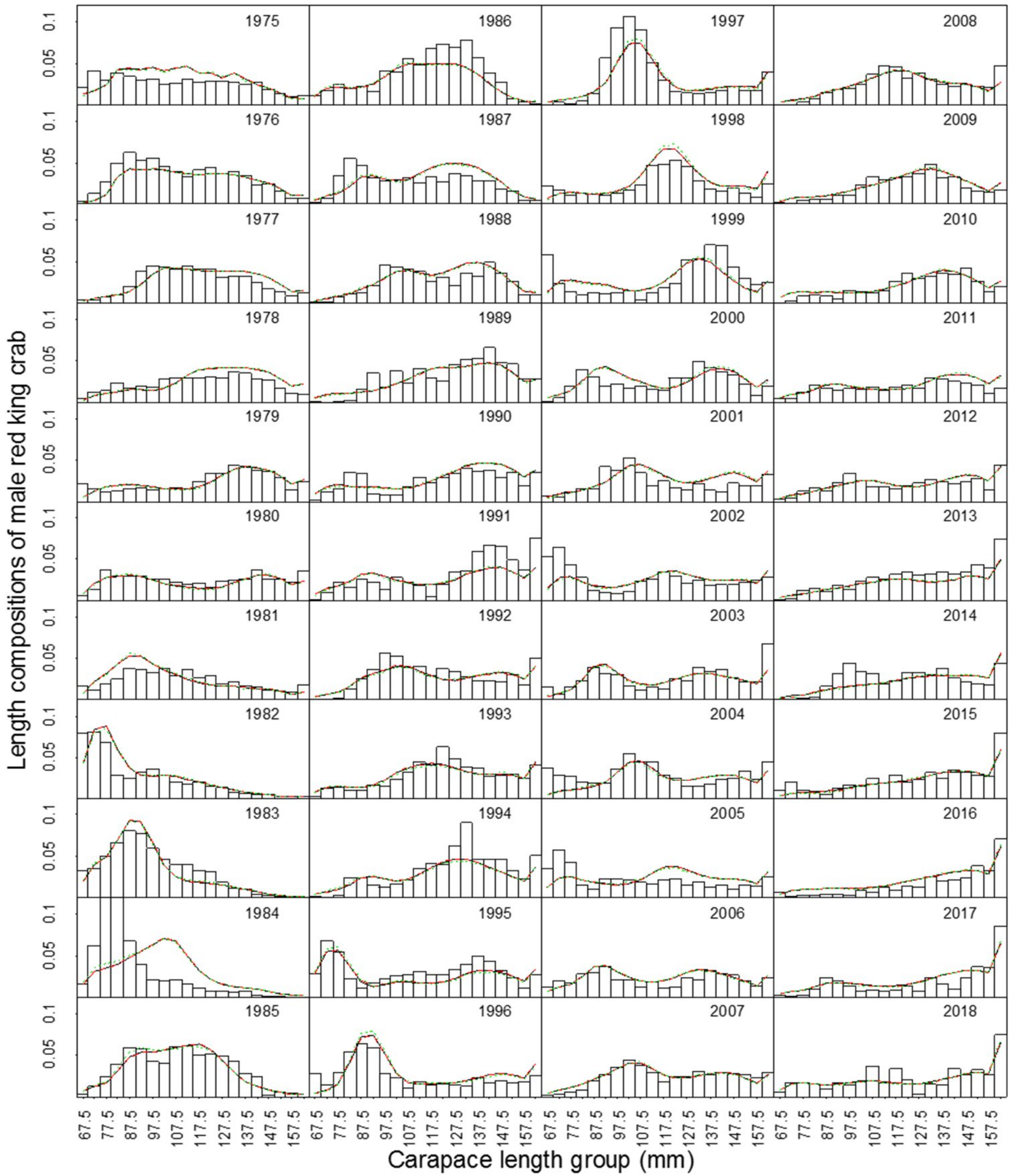
Estimated selectivities of NMFS trawl survey during 1982-2018 with different dataset of BSFRF survey data and five scenarios



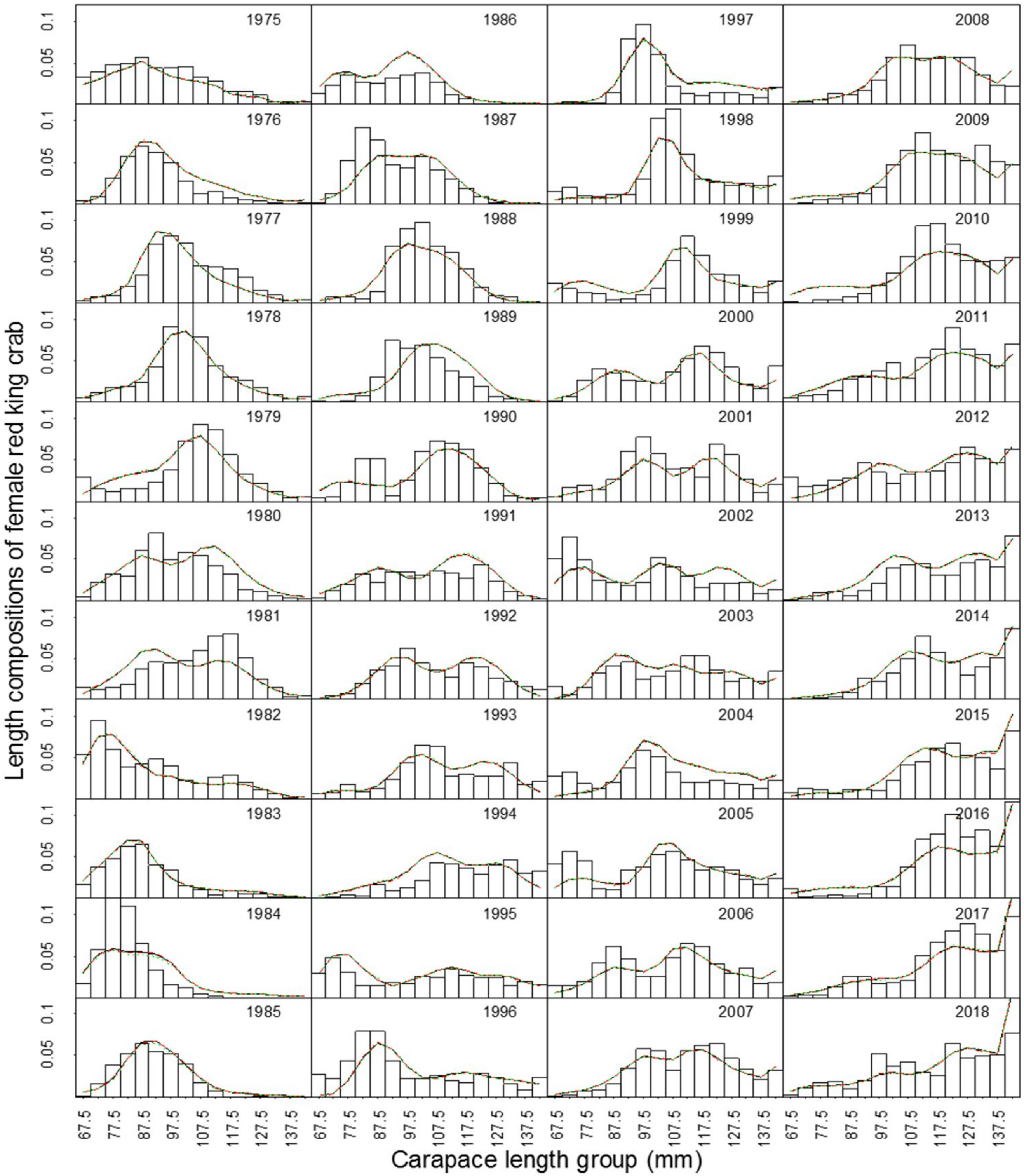
Estimated selectivities of BSFRF trawl survey during 2007-08 and 2013-2016 with five scenarios



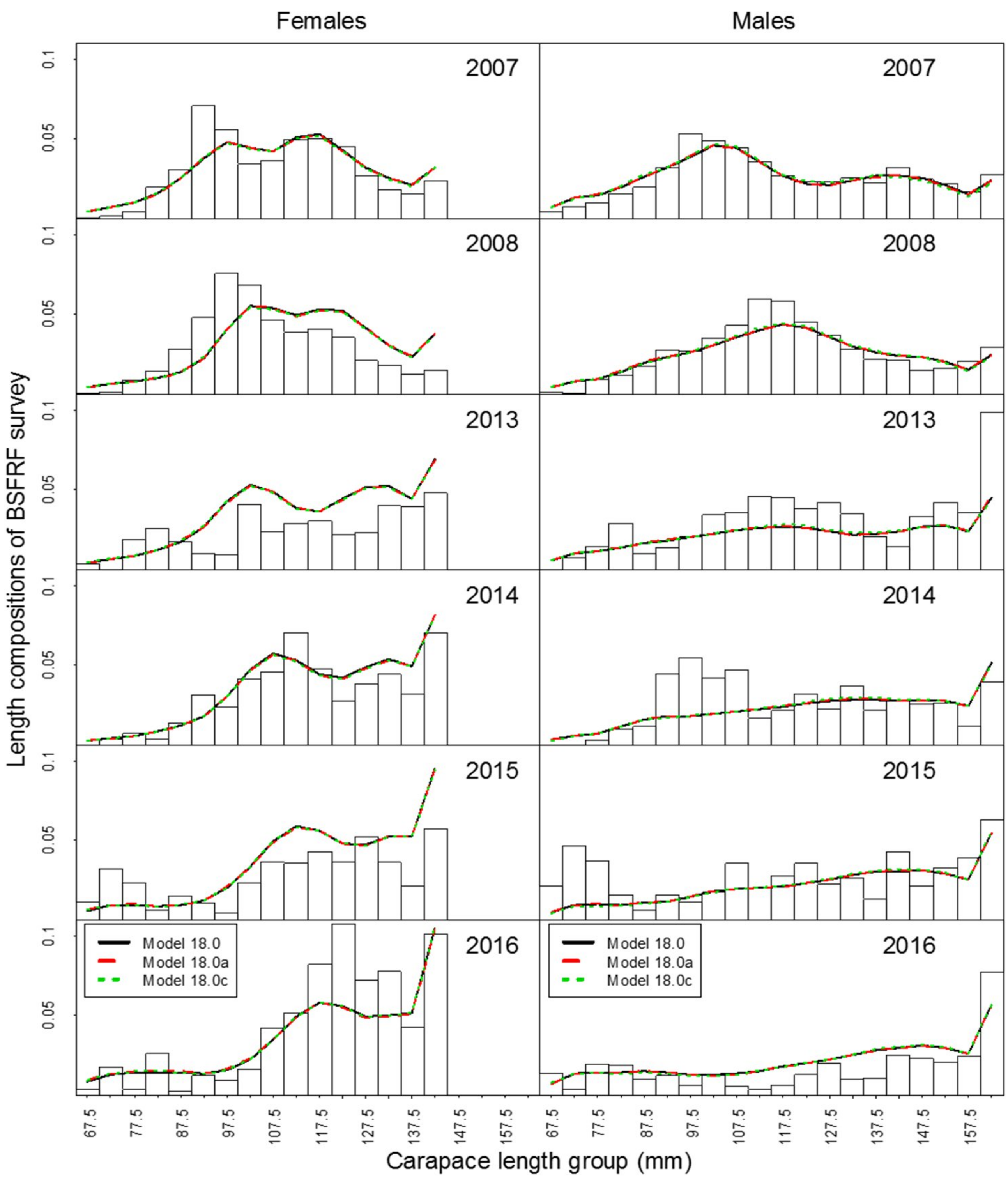
Scenario 18.0



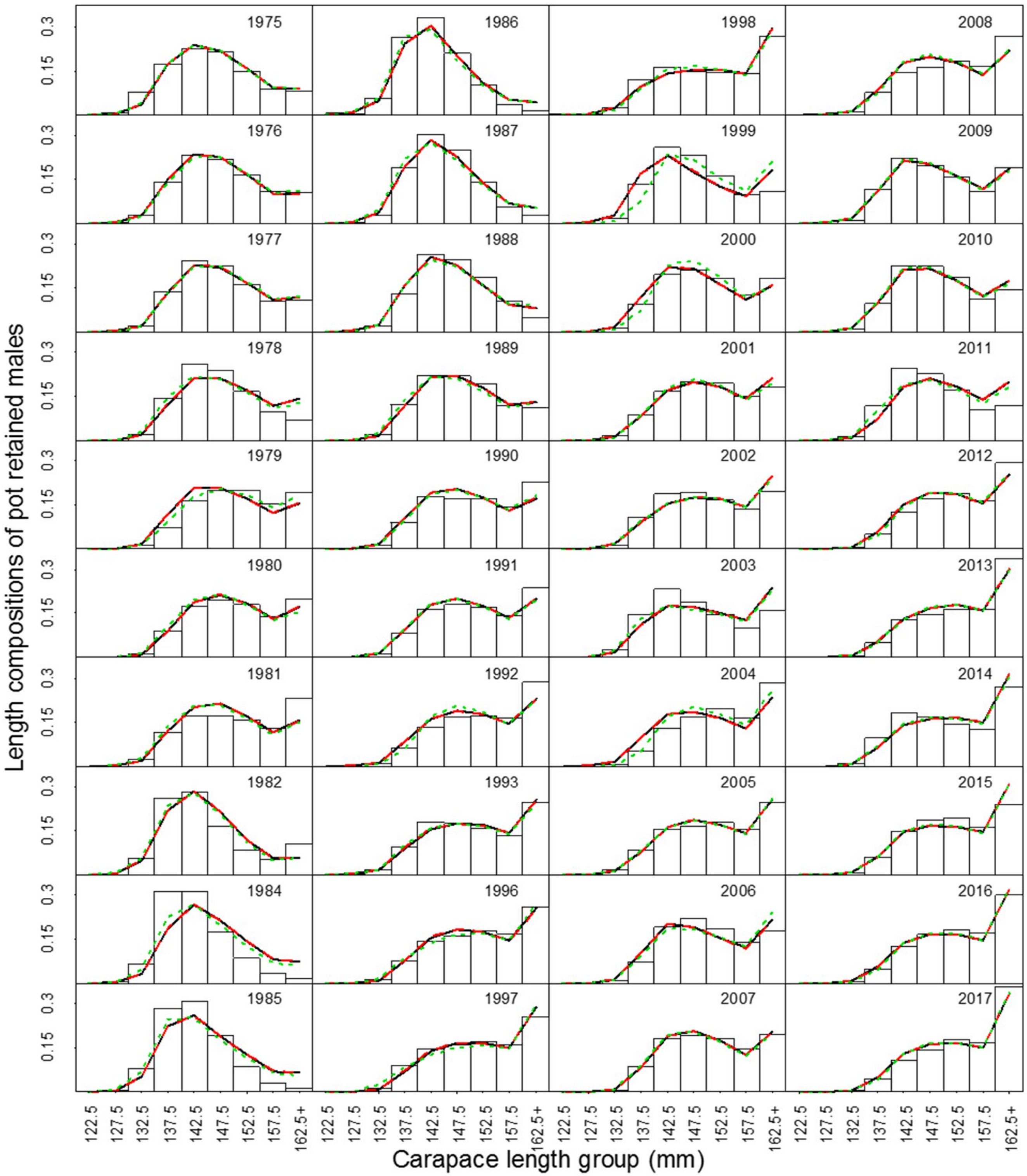
Comparison of area-swept and model estimated NMFS survey length frequencies of Bristol Bay male red king crab by year under scenarios 18.0(solid black), 18.0a(dashed red), and 18.0c (green lines)



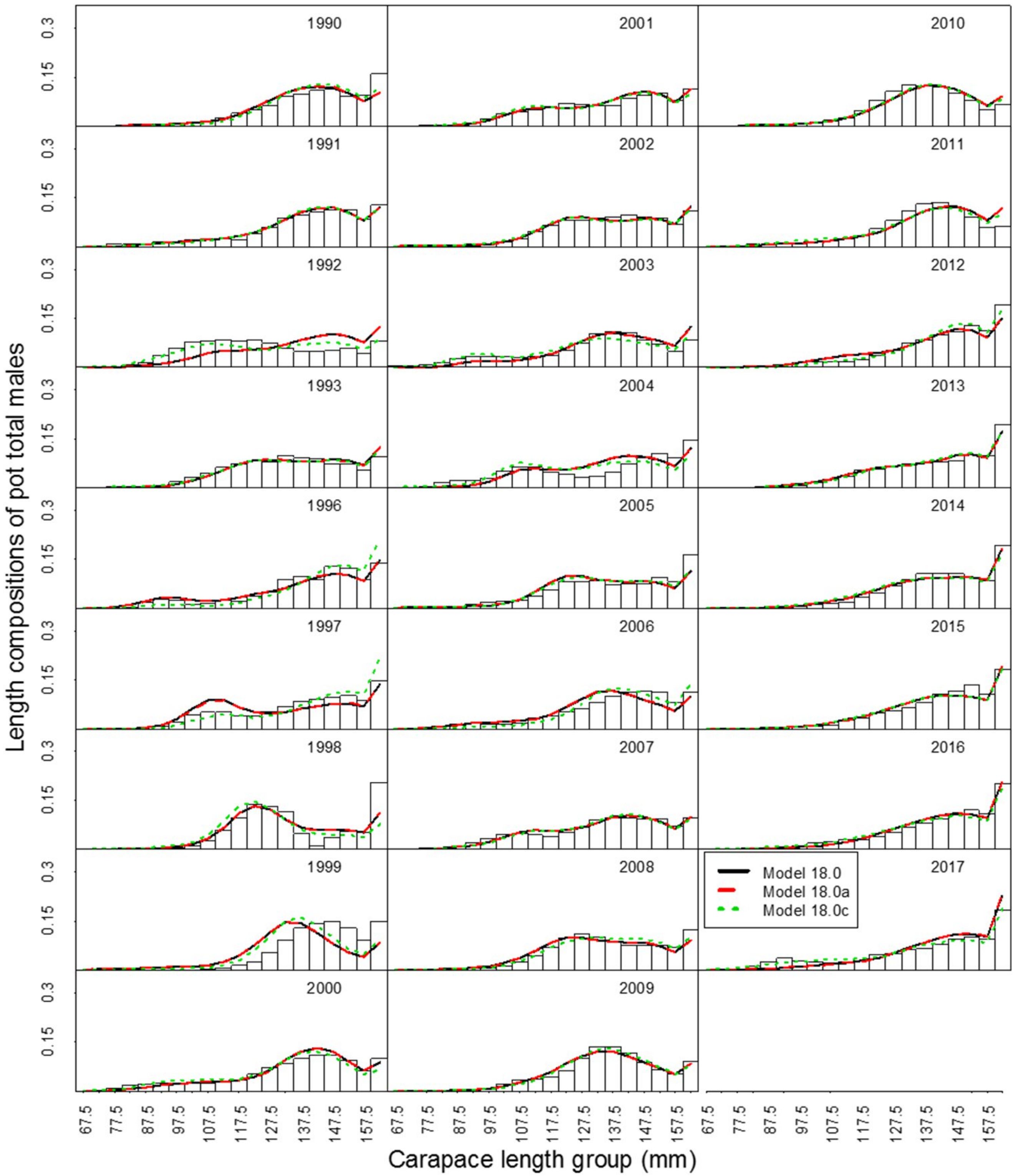
Comparison of area-swept and model estimated NMFS survey length frequencies of Bristol Bay female red king crab by year under scenarios 18.0(solid black), 18.0a(dashed red), and 18.0c (green lines)



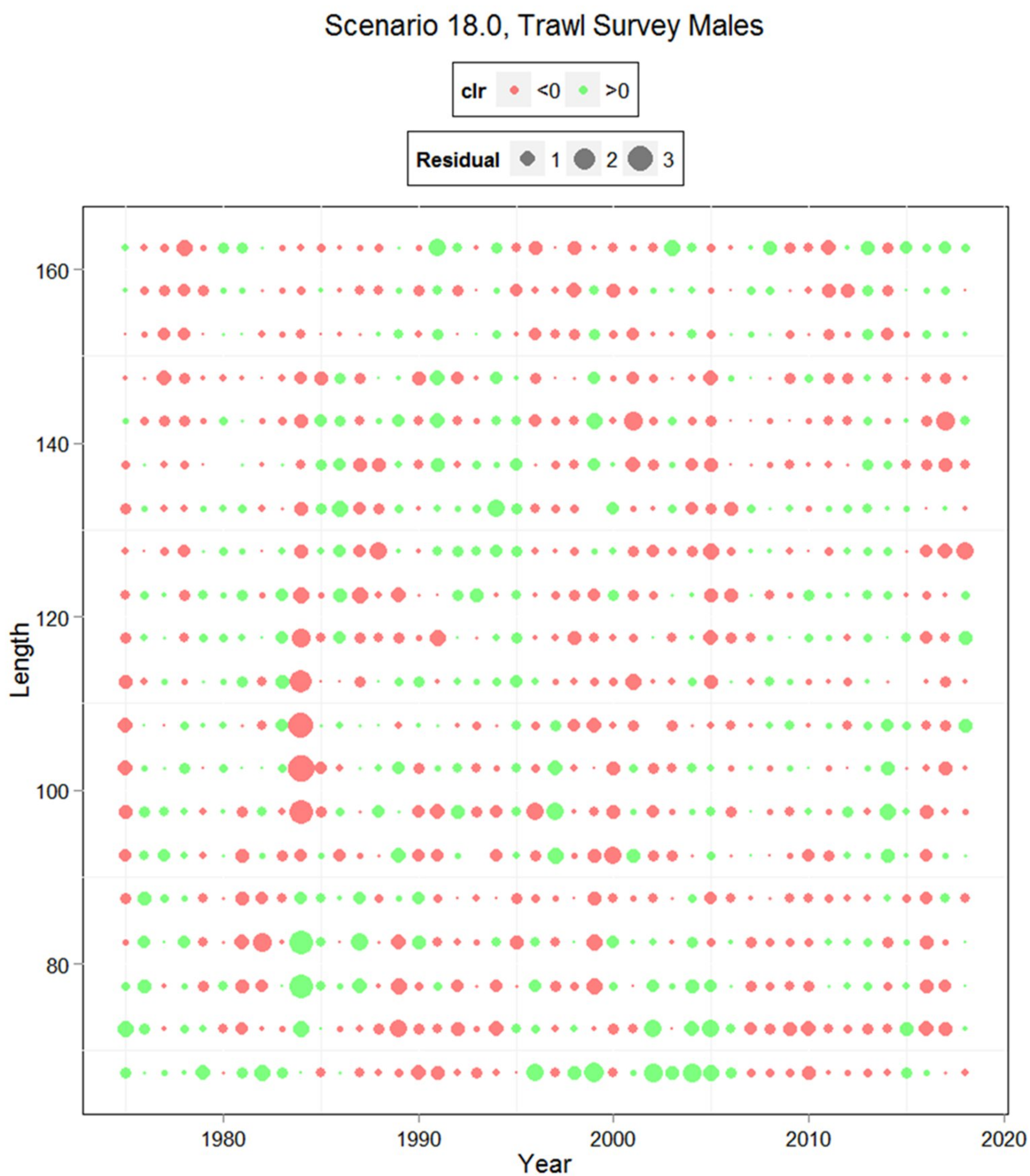
Comparison of area-swept and model fits of BSFRF survey length compositions with scenarios 18.0 (black lines), 18.0a (red lines), and 18.0c (green lines)

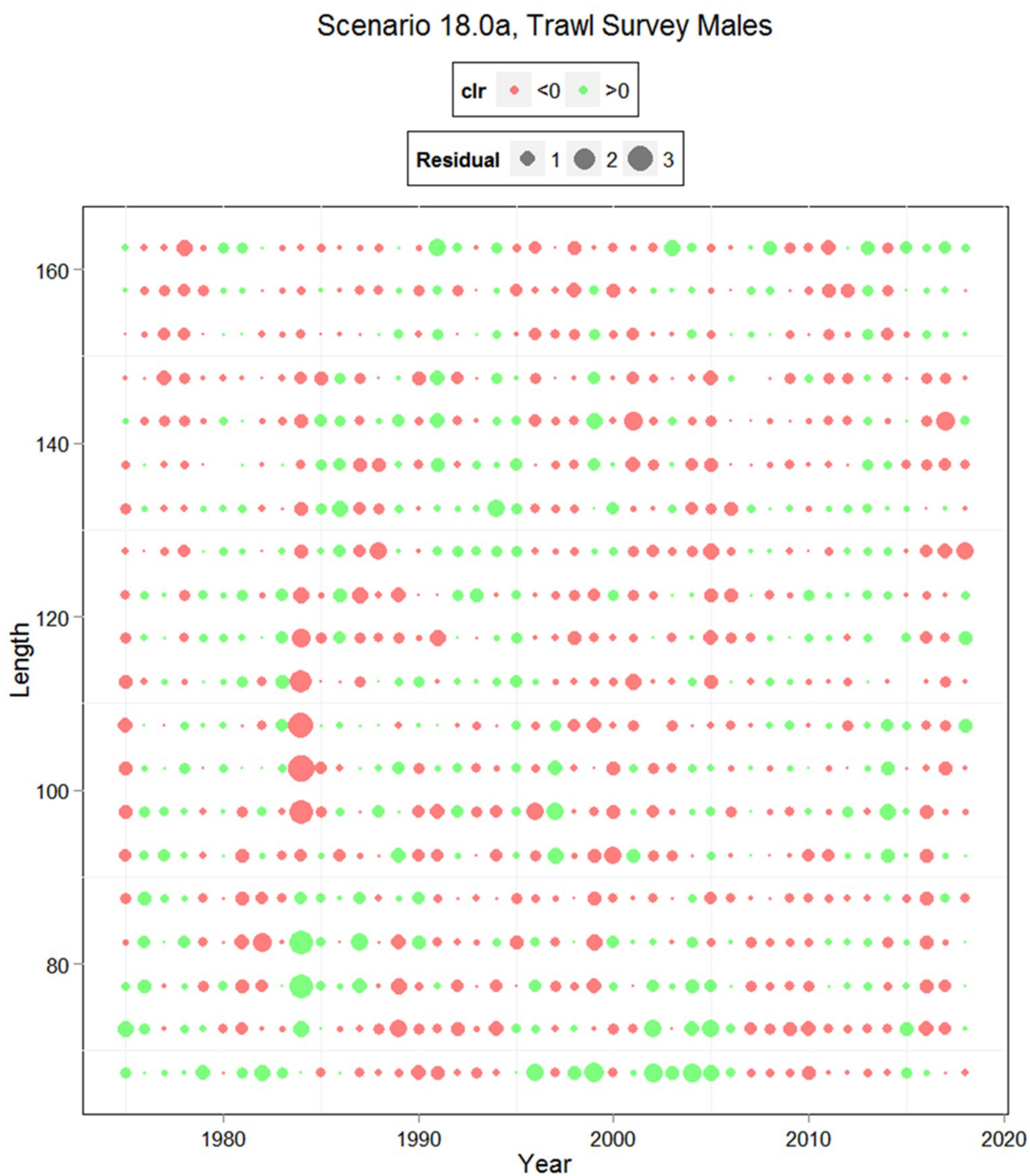


Comparison of observer and model estimated retained length frequencies of Bristol Bay male red king crab by year in the directed pot fishery under scenarios 18.0(solid black), 18.0a (dashed red), and 18.0c (green lines).

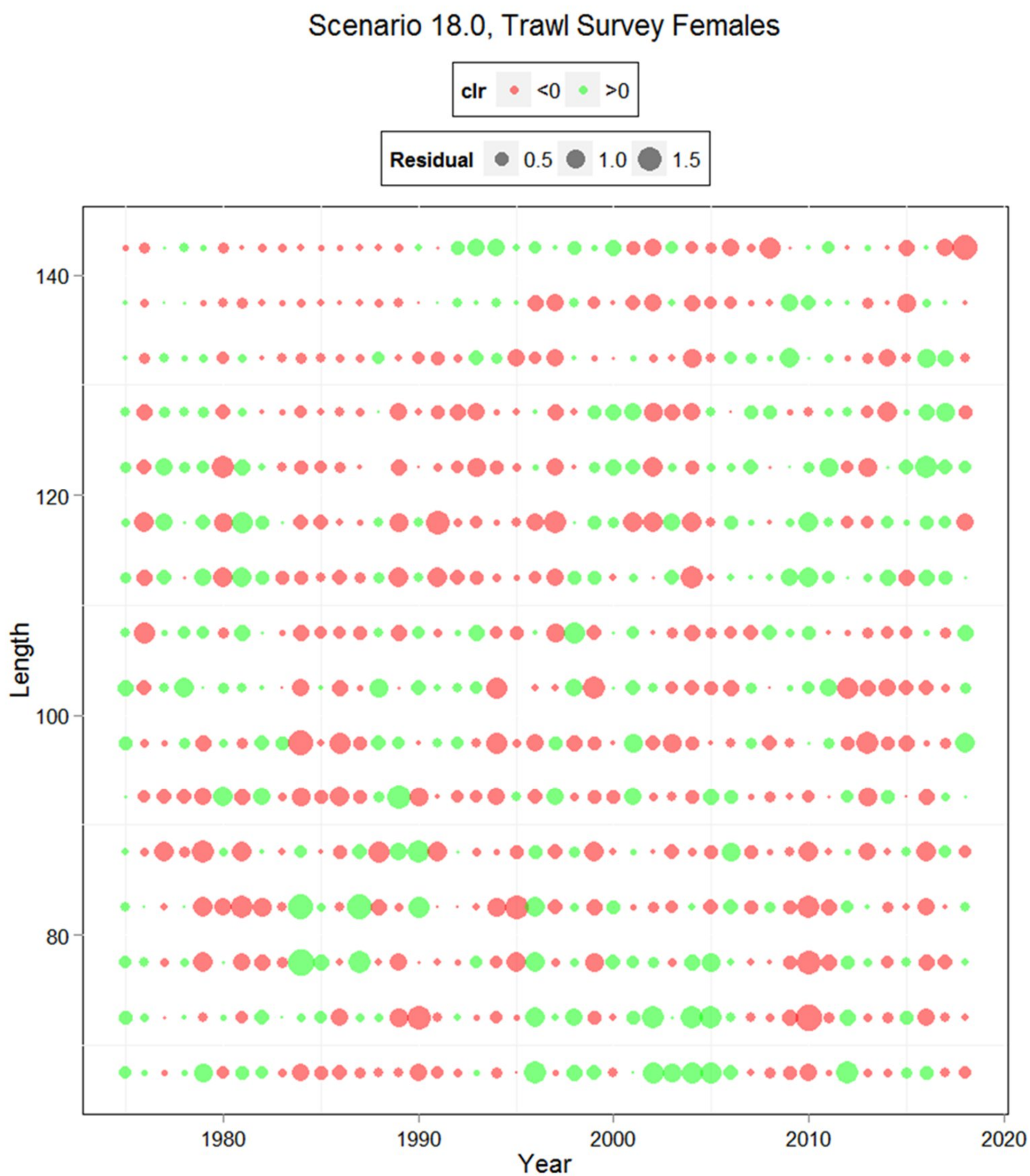


Comparison of observer and model estimated total length frequencies of Bristol Bay male red king crab by year in the directed pot fishery under scenarios 18.0 (solid black, 18.0a (dashed red), and 18.0c (green lines).


Scenario 18.0, Trawl Survey Males
clr
<0
>0
Residual
1
2
3
Length
160
140
120
100
80
Year
1980
1990
2000
2010
2020



Scenario 18.0a, Trawl Survey Males
clr
<0
>0
Residual
1
2
3
Length
160
140
120
100
80
Year
1980
1990
2000
2010
2020


Scenario 18.0, Trawl Survey Females
clr
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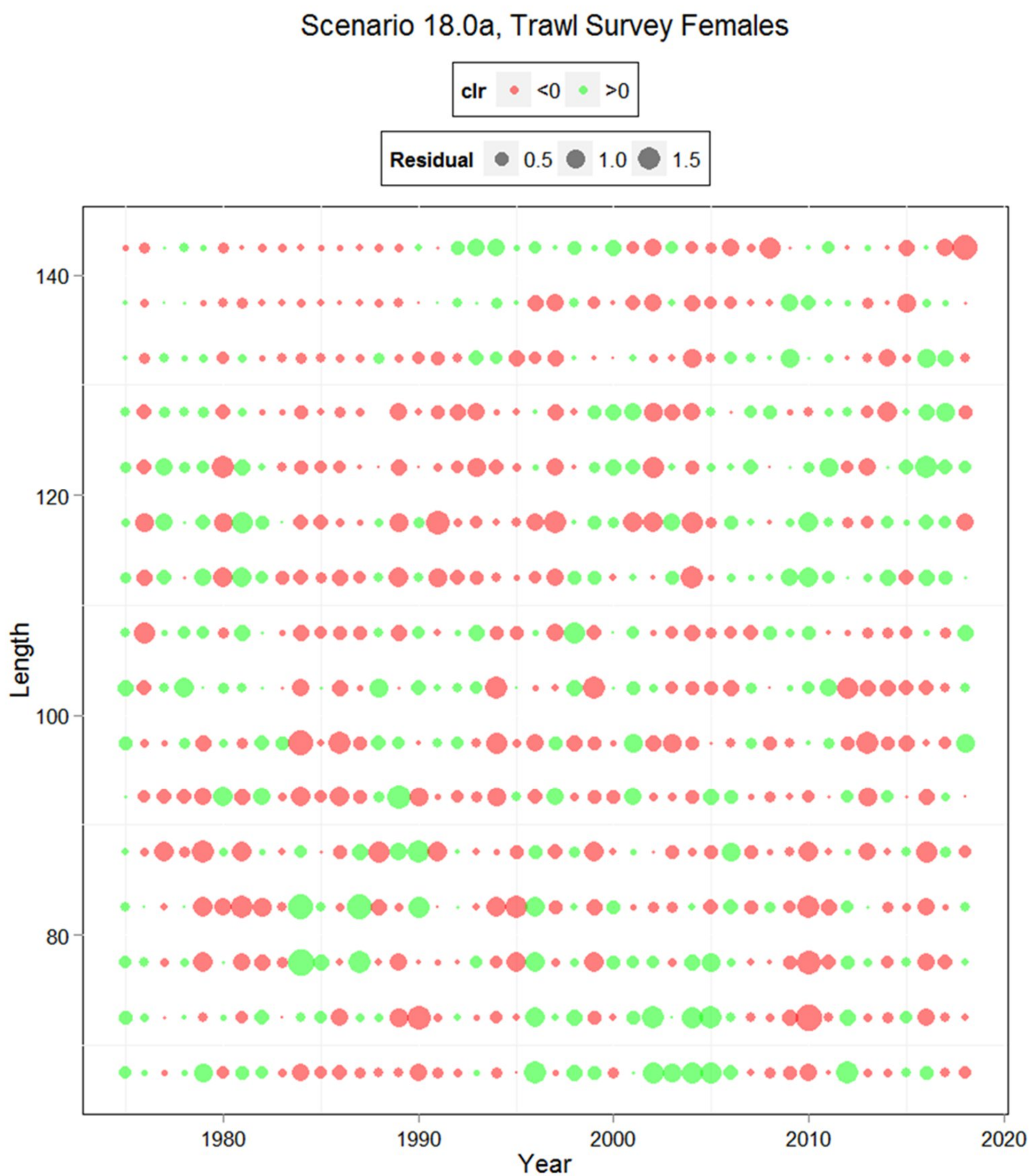
>0
Residual
0.5
1.0
1.5
Length
140
120
100
80
1980
1990
2000
2010
2020
Year

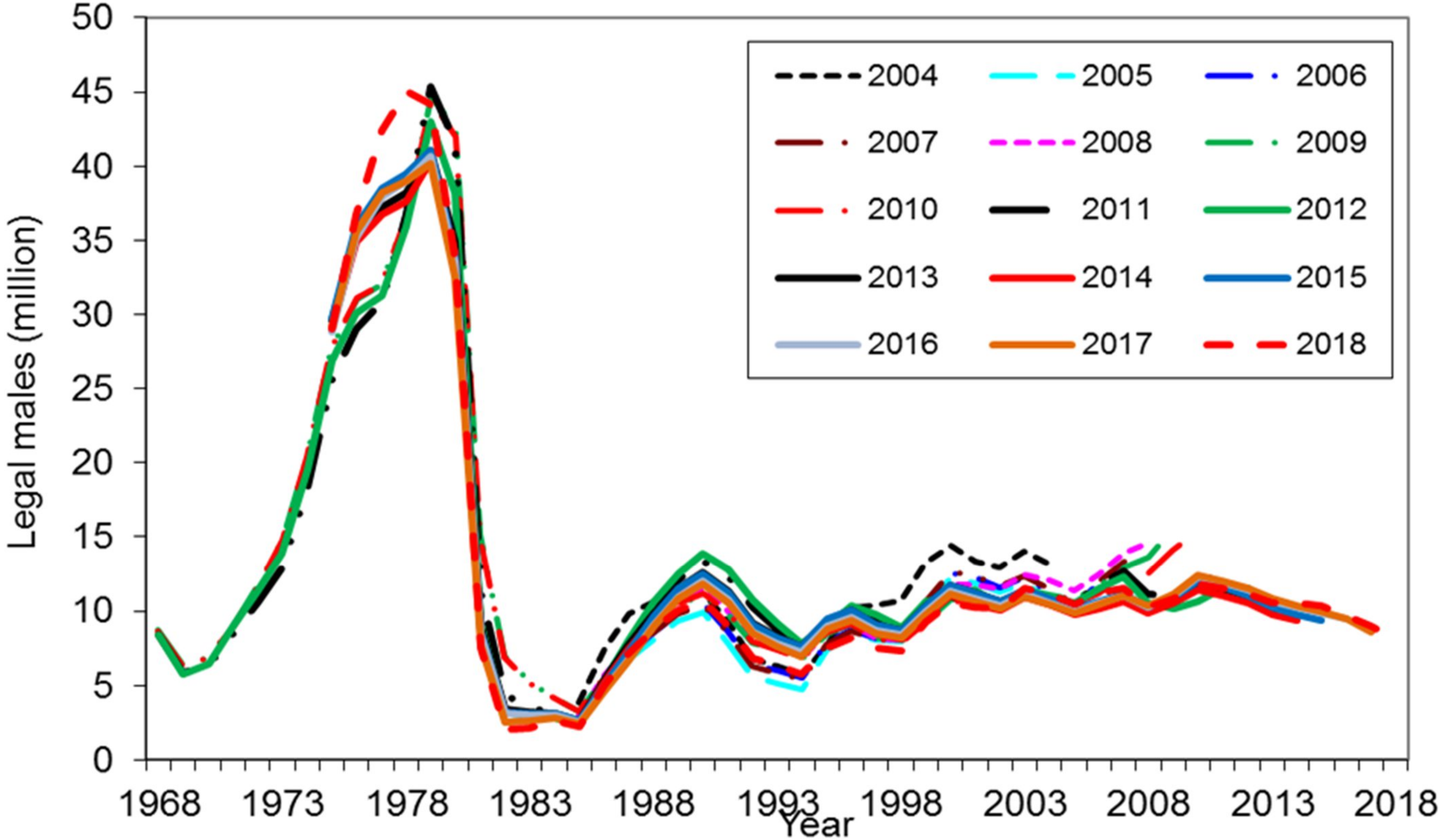


Scenario 18.0a, Trawl Survey Females
clr
<0
>0
Residual
0.5
1.0
1.5
Length
140
120
100
80
1980
1990
2000
2010
2020
Year

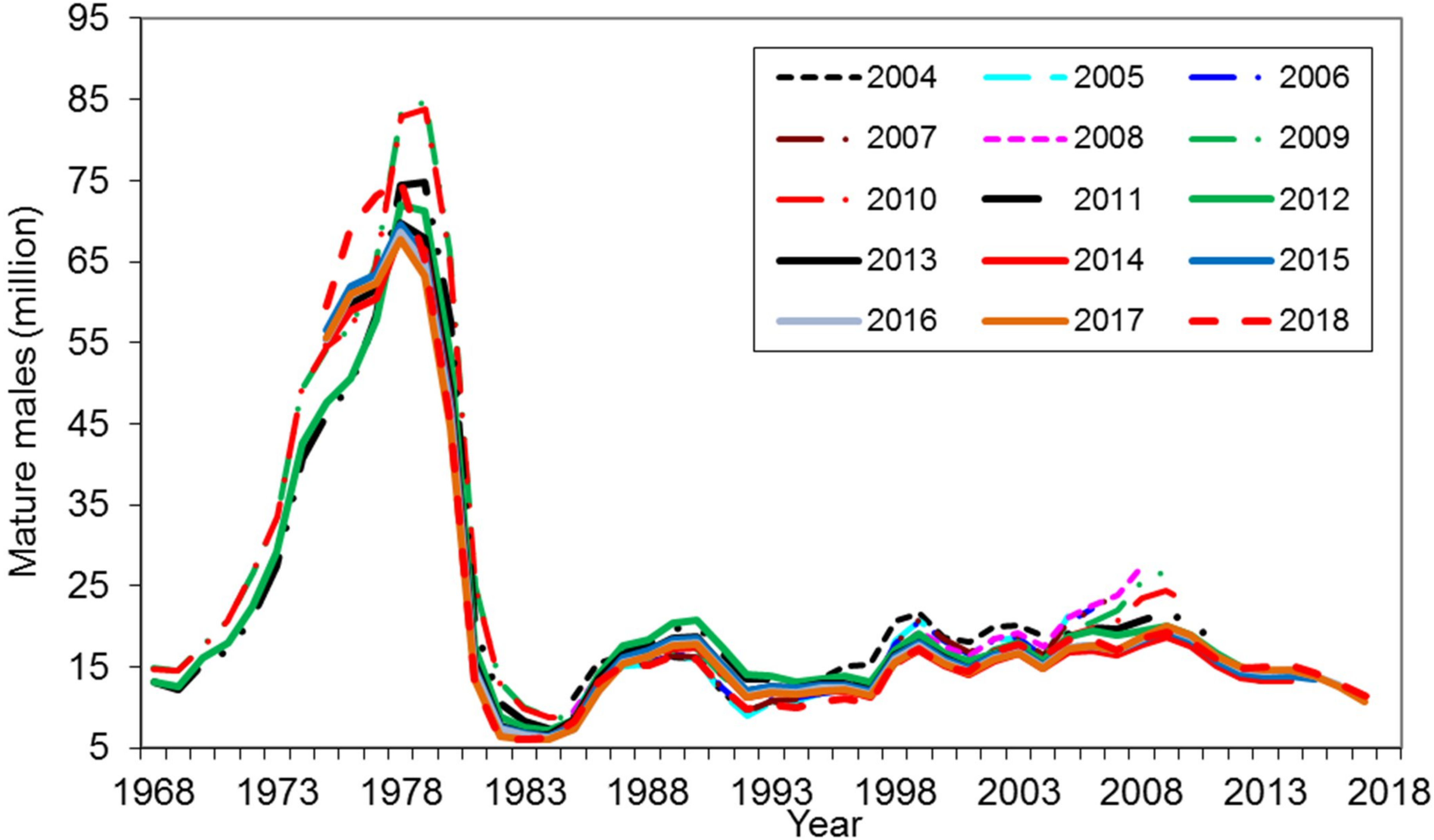
Scenario

Negative log likelihood	18.0	18.0a	18.0b	18.0c	2b	18.0-18.0b	18.0-18.0c	18.0-2b	18.0b-18.0c
R-variation	65.0	64.7	65.6	65.8	65.6	-0.54	-0.77	-0.55	-0.23
Length-like-retained	-1109.7	-1109.7	-1104.3	-1124.5	-1102.6	-5.43	14.77	-7.15	20.20
Length-like-tot/dis male	-1273.8	-1274.2	-1274.9	-1296.9	-1133.1	1.11	23.07	-140.71	21.96
Length-like-discfemale	-859.4	-859.4	-854.9	-854.7	-845.0	-4.49	-4.70	-14.41	-0.22
Length-like-survey	-5096.2	-5097.4	-5096.7	-5098.4	-5070.7	0.54	2.23	-25.48	1.69
Length-like-disctrawl	-3918.1	-3935.9	-3922.1	-3926.5	-3913.2	3.98	8.37	-4.89	4.39
Length-like-discfix	-880.6	-887.4	-881.2	-879.6	-878.2	0.63	-1.01	-2.34	-1.63
Length-like-discTanner	-480.5	-491.8	-480.4	-480.4	-477.4	-0.18	-0.10	-3.13	0.07
Length-like-bsfrfsurvey	-649.7	-650.7	-649.8	-650.2	-644.9	0.15	0.52	-4.76	0.37
Catchbio_retained	16.7	16.7	14.6	9.2	27.5	2.11	7.55	-10.83	5.44
Catchbio_tot/discmale	58.2	58.4	48.1	21.7	135.8	10.11	36.44	-77.67	26.33
Catchbio-discfemale	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
Catchbio-disctrawl	0.0	0.0	0.0	0.0	0.0	0.00	0.00	-0.01	0.00
Catchbio-discfix	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
Catchbio-discTanner	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
Biomass-trawl survey	115.3	115.9	115.2	116.9	112.4	0.10	-1.59	2.84	-1.69
Biomass-bsfrfsurvey	-10.8	-10.9	-10.9	-11.1	-10.0	0.18	0.38	-0.81	0.20
Q-trawl survey	0.7	0.7	0.6	0.9	0.2	0.07	-0.20	0.48	-0.26
Others	18.1	18.1	22.1	19.6	18.0	-4.03	-1.45	0.13	2.58
Total	-14005	-14043	-14009	-14088	-13715	4.30	83.50	-289.30	79.20
Free parameters	299	299	311	368	298	-12	-69	1	-57
B35%(t)	25540	25479	25514	25920	24910	26.30	-380.10	630.40	-406.40
F35%	0.31	0.31	0.32	0.30	0.30	-0.01	0.01	0.01	0.02
MMB2018(t)	20617	20804	20581	20940	19820	35.60	-323.70	797.00	-359.30
OFL2018	5207	5336	5137	5236	4789	69.88	-28.77	417.78	-98.65
ABC2018(t)	4686	4803	4623	4712	4310	62.89	-25.89	376.00	-88.78
Fofl2018	0.244	0.247	0.251	0.236	0.232	-0.01	0.01	0.01	0.02
Q	0.925	0.925	0.923	0.929	0.911	0.00	0.00	0.01	-0.01

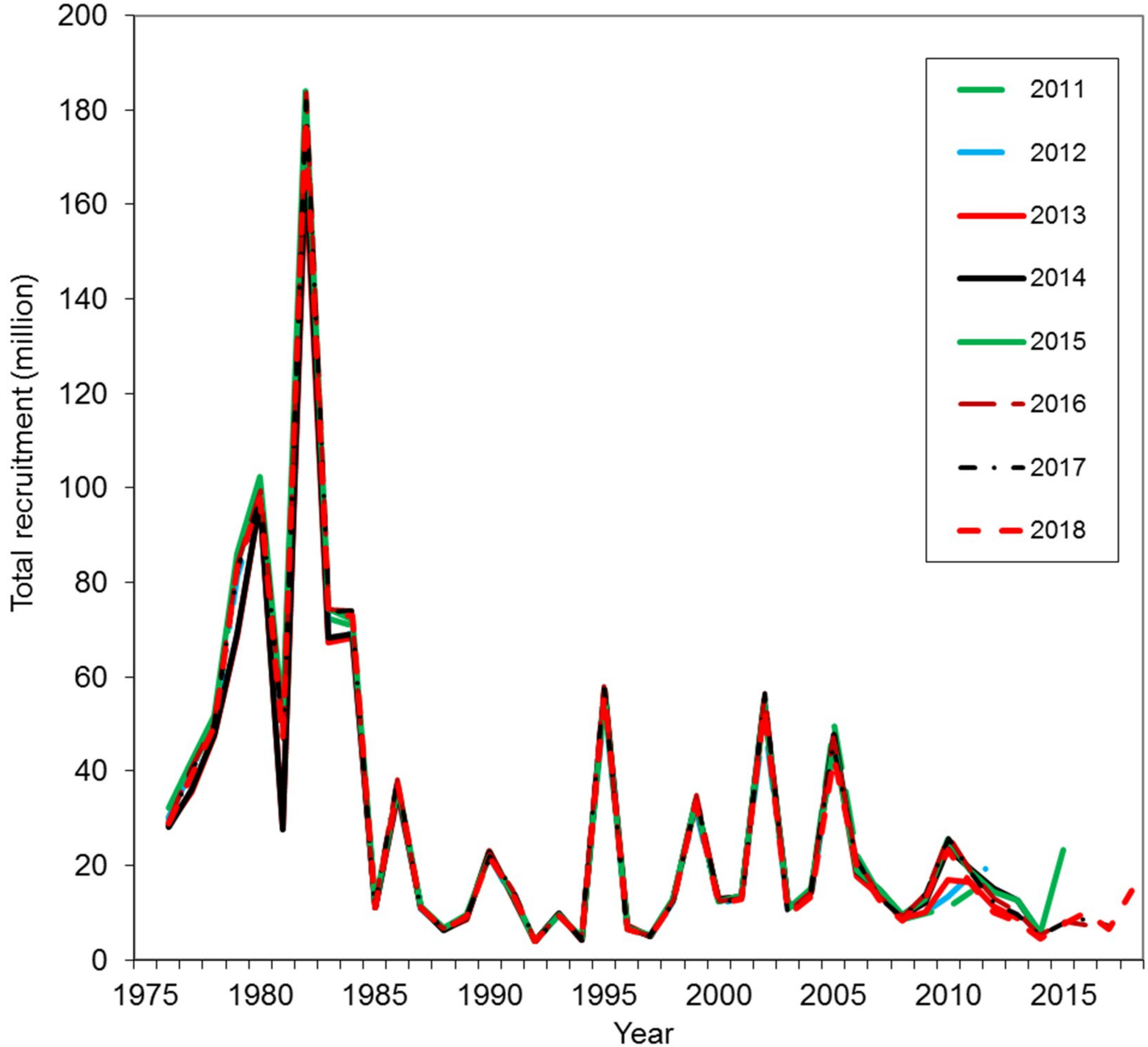
Scenario 18.0 for 2018, historical results



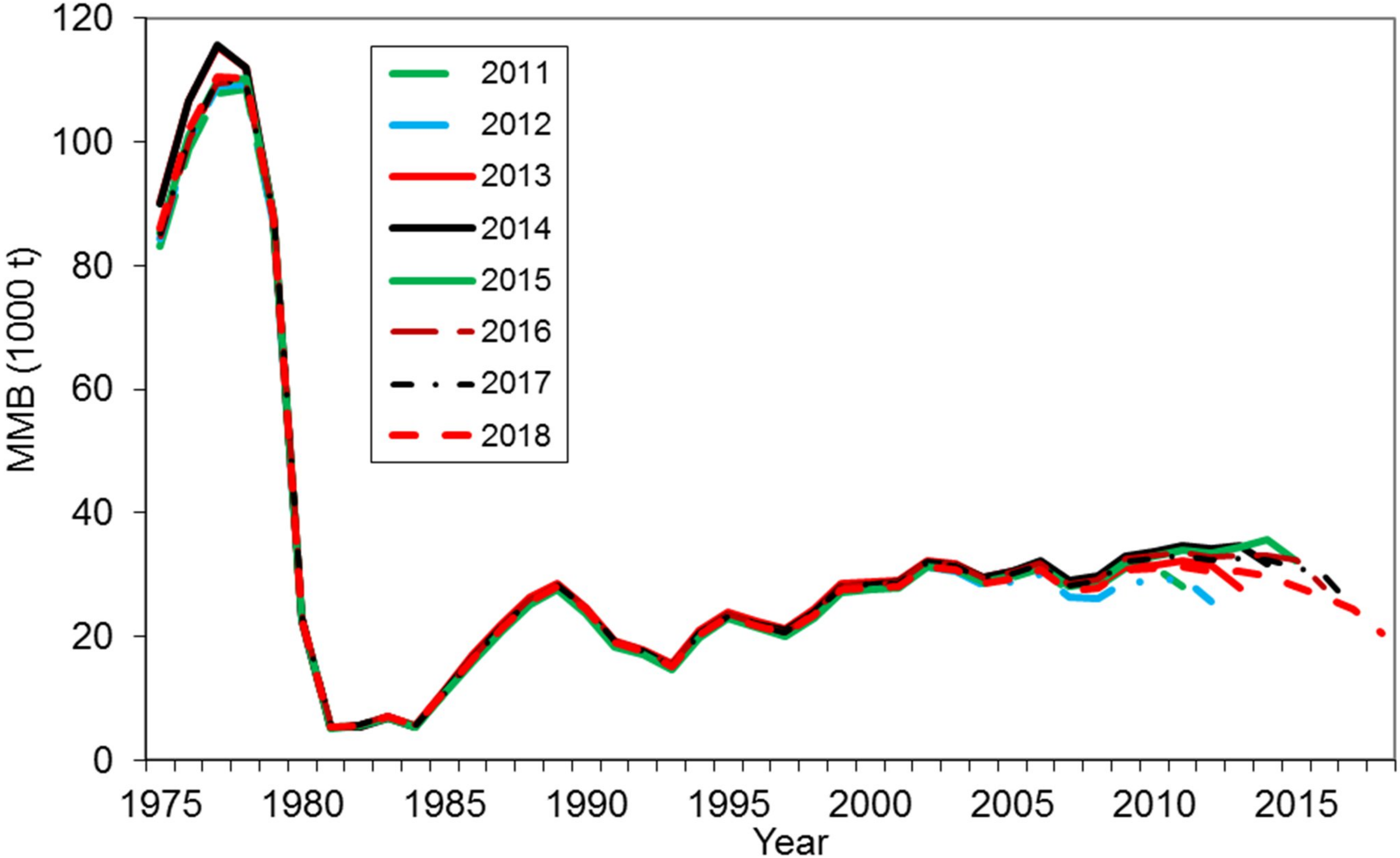
Scenario 18.0 for 2018, historical results



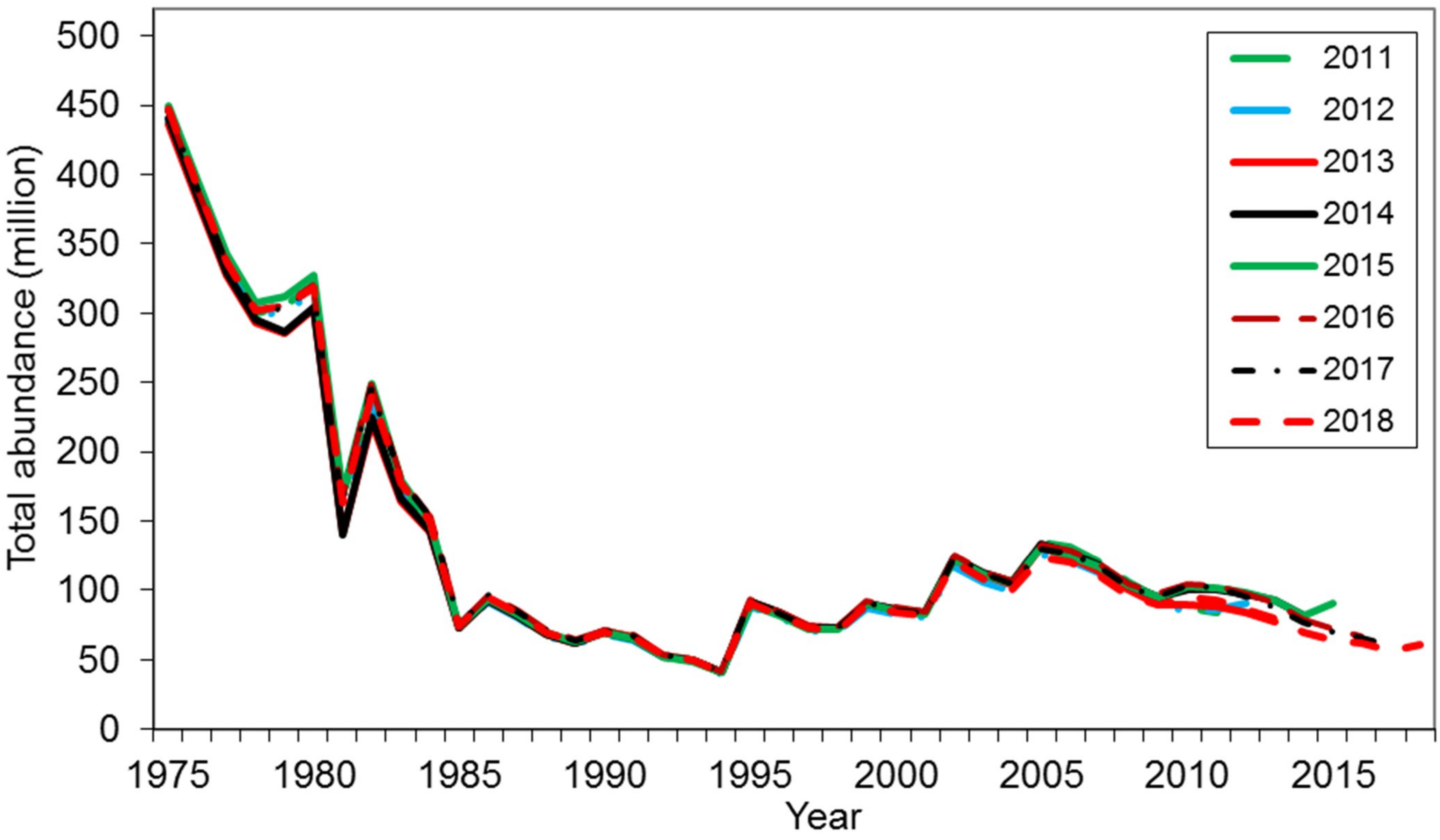
Comparison of hindcast estimates of total recruitment for scenario 18.0 from 1976 to 2018 made with terminal years 2011-2018.



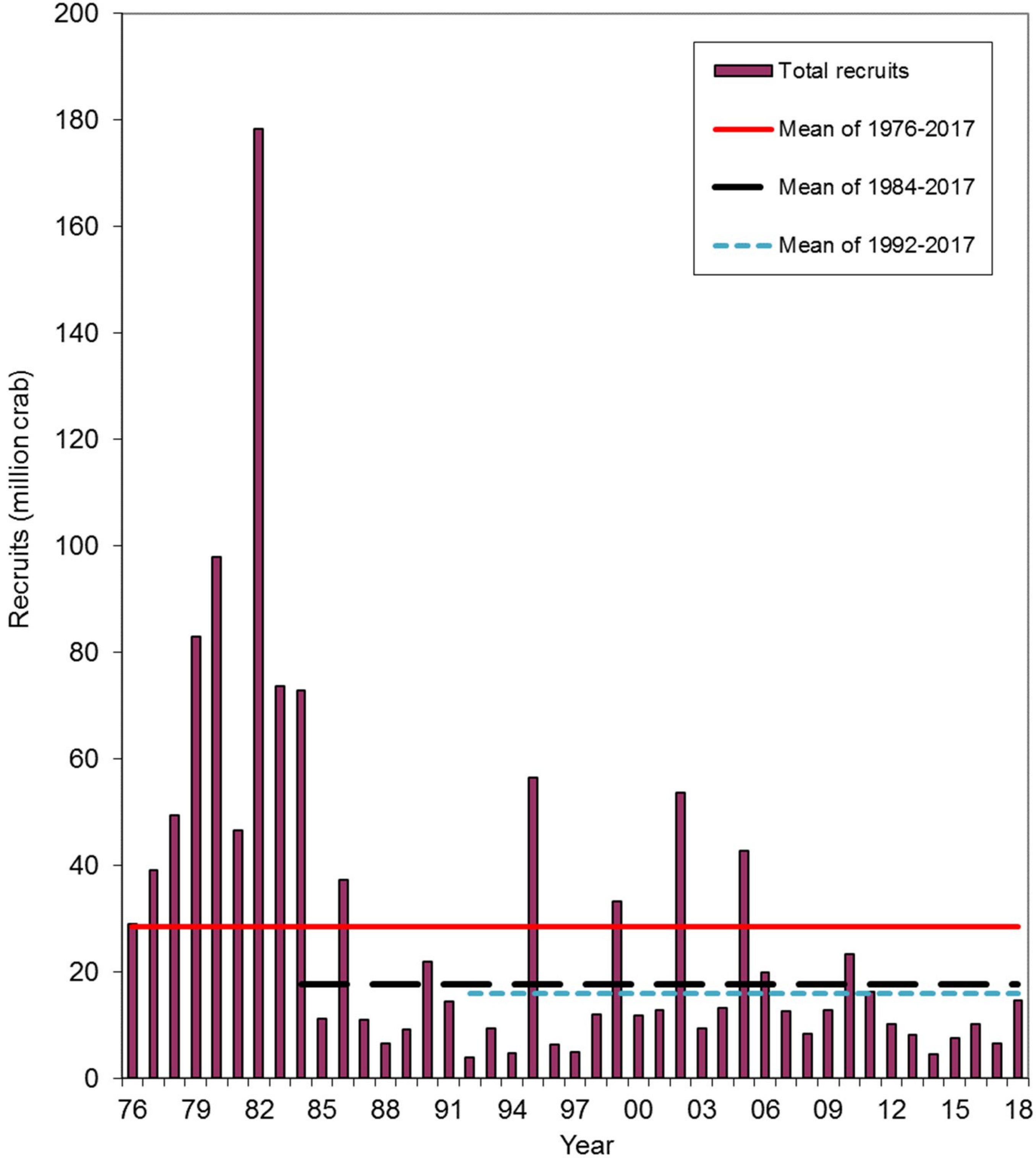
Scenario 18.0, 2018 model results

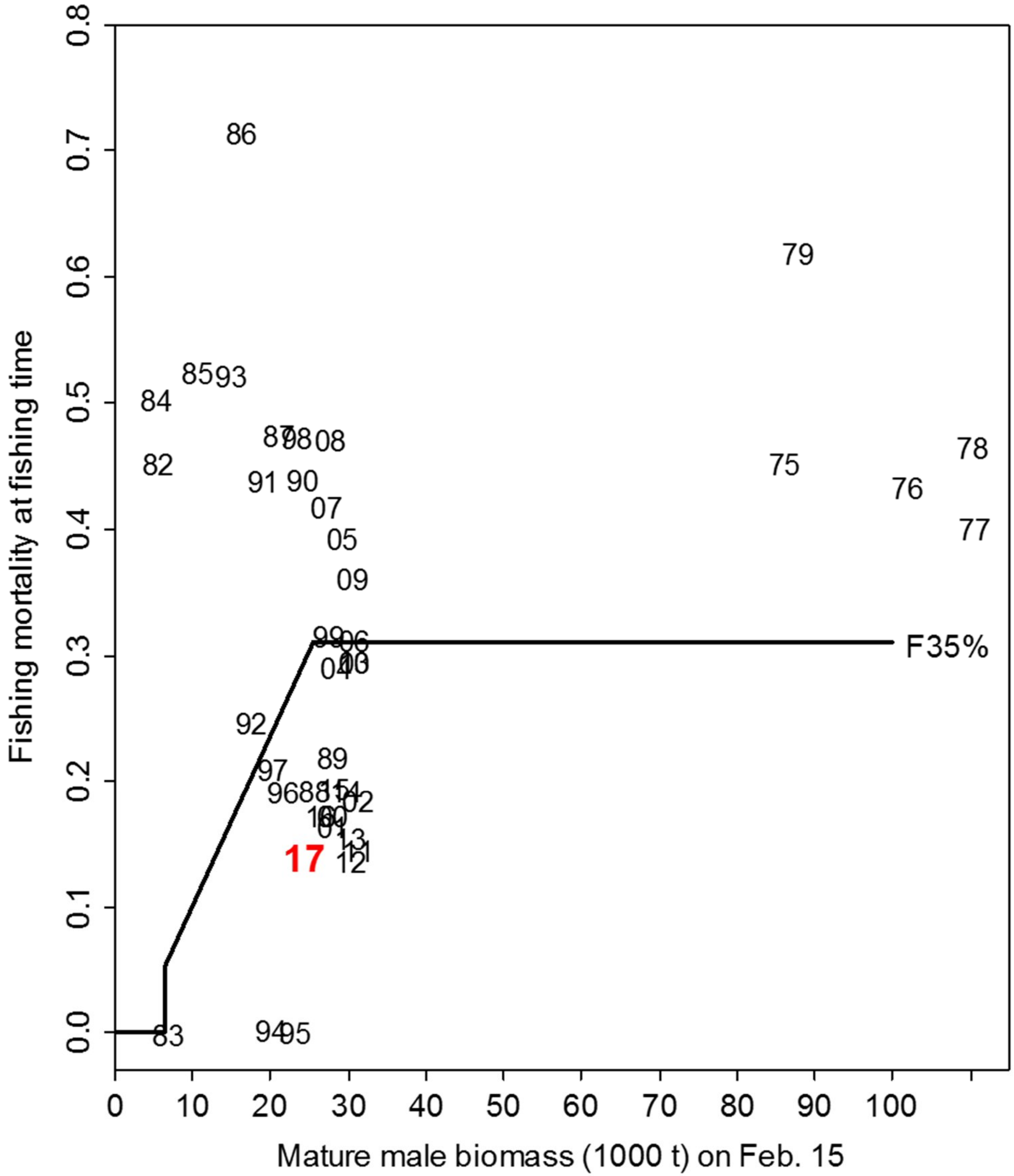


Scenario 18.0, 2018 model results



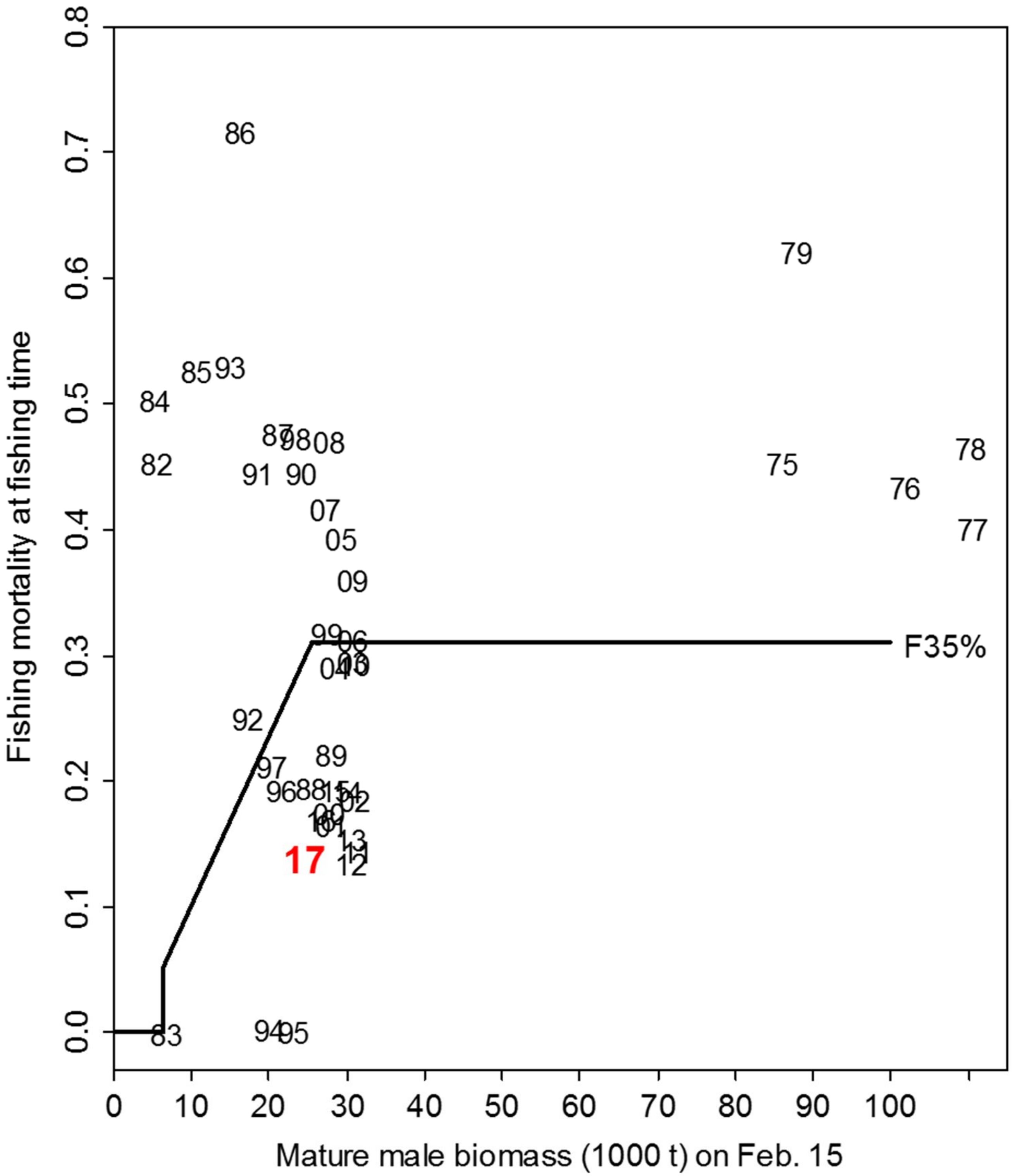
Scenario 18.0

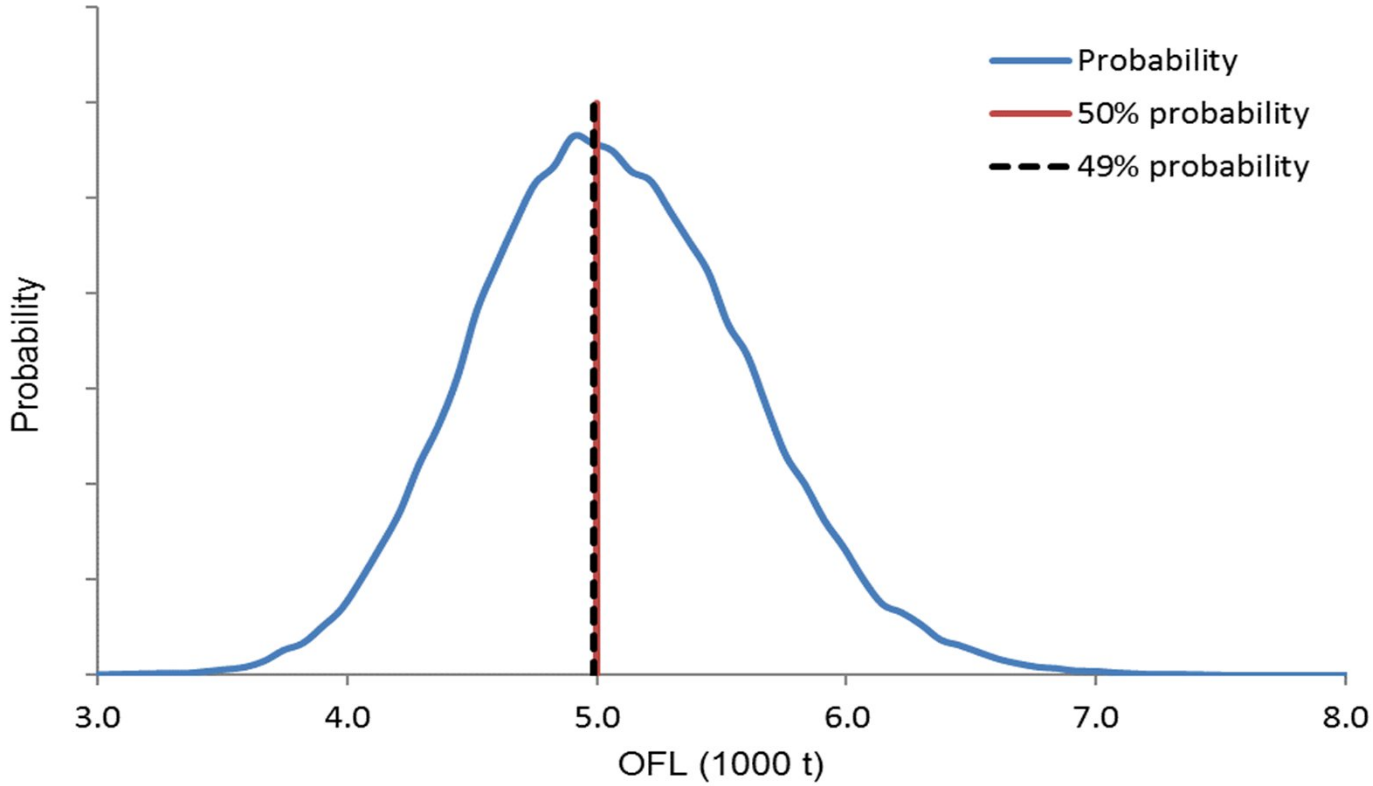




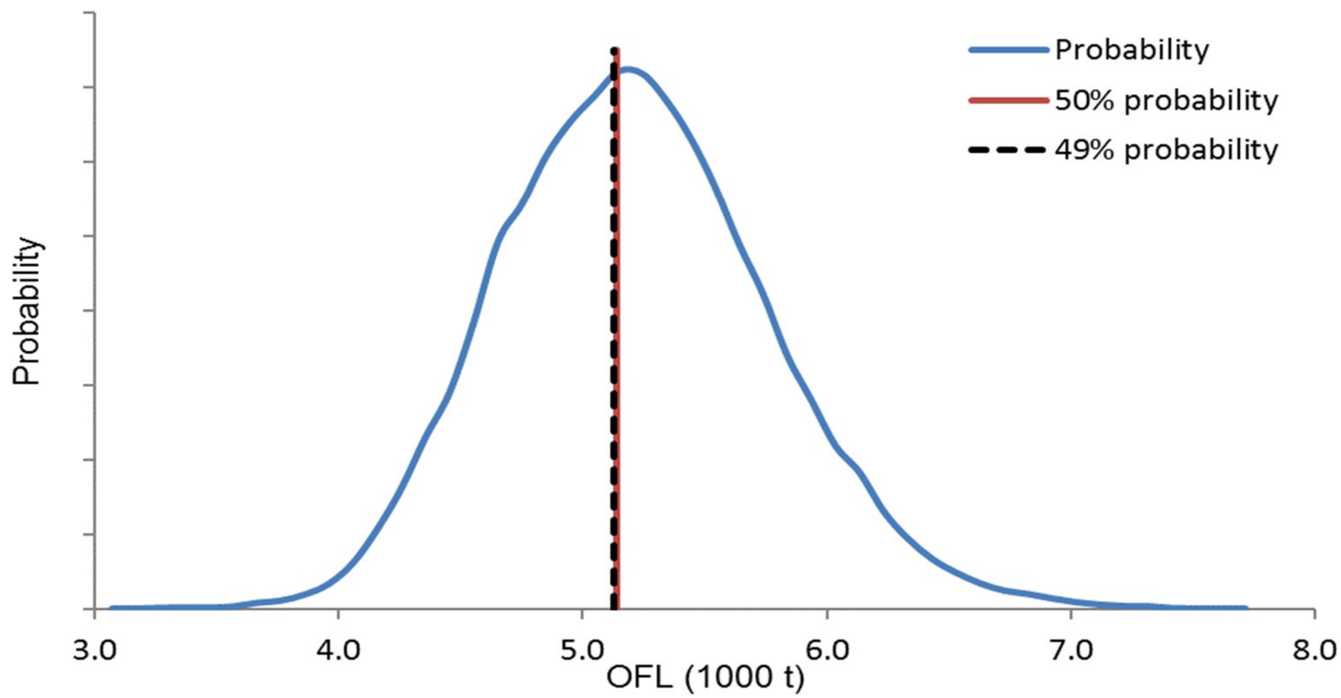
Scenario 18.0

Scenario 18.0a



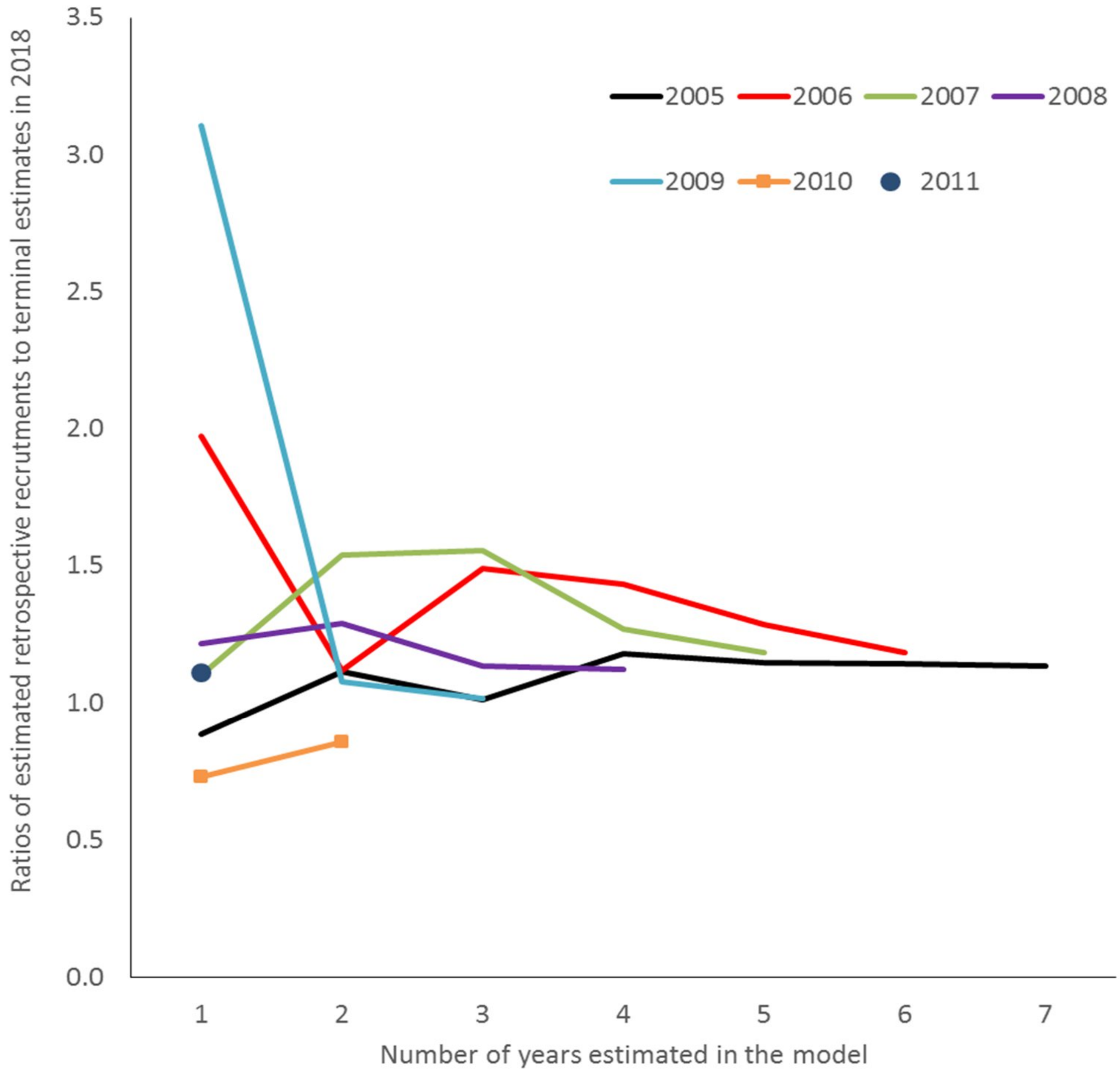


Scenario 18.0
2018

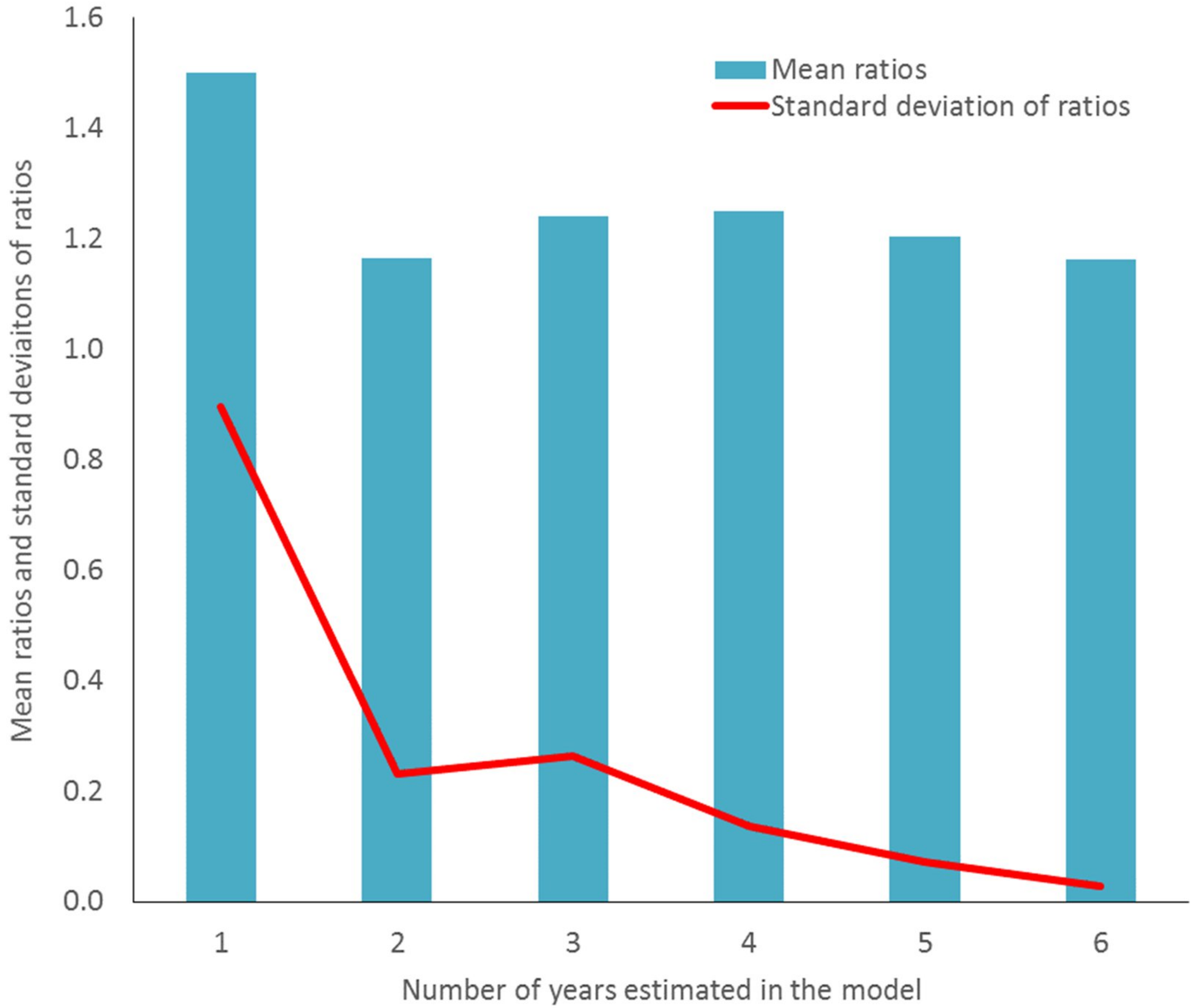


Scenario 18.0a
2018

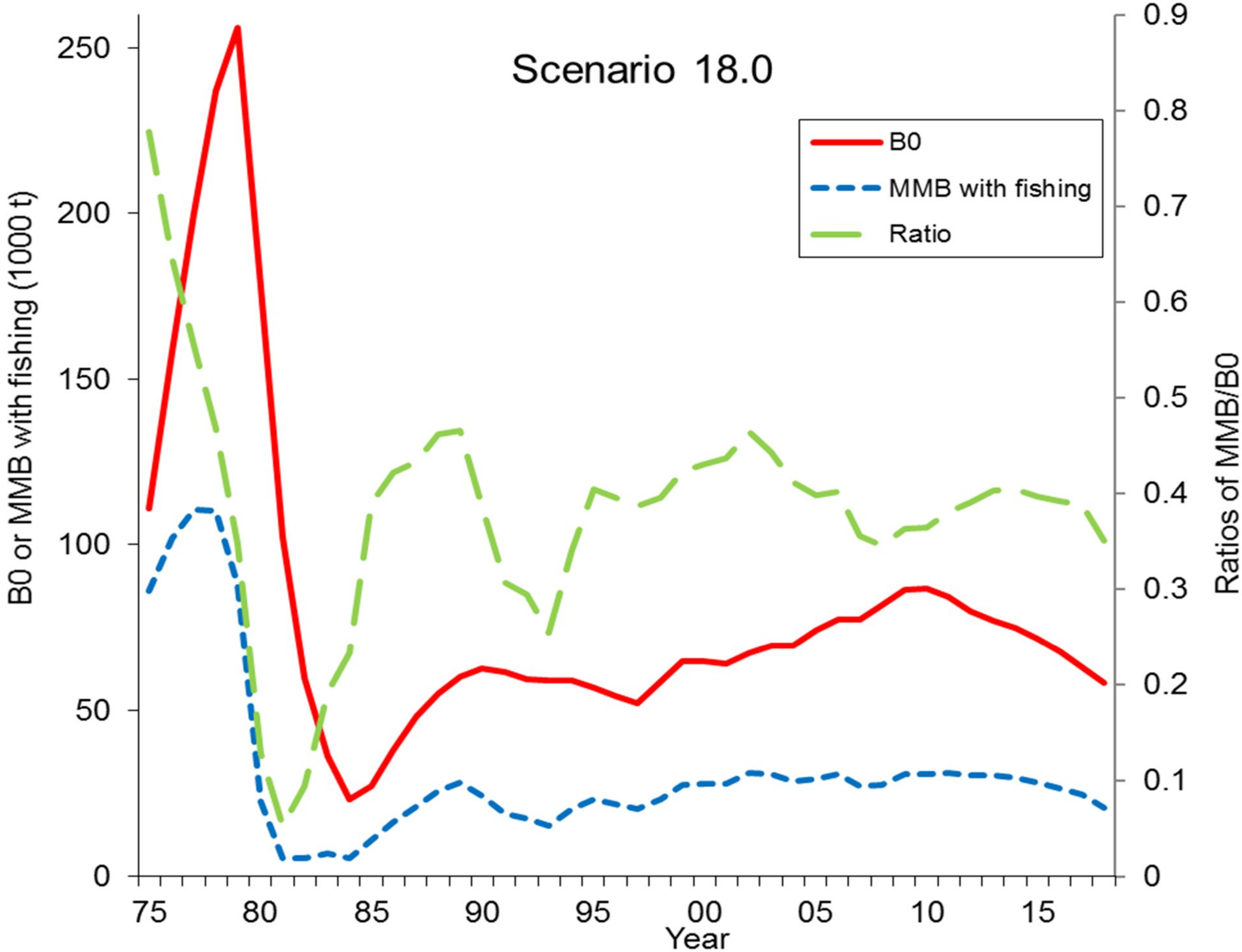
Evaluation of retrospective errors on recruitment estimates as a function of the number of years in the model for scenario 18.0



Mean ratios of retrospective estimates of recruitments to those estimated in the most recent year (2018) and Sdev. of the ratios as a function of the number of years in the model for scenario 18.0.



Estimated B0, MMB with fishing, and ratios of MMB/B0 from 1975 to 2018 for scenario 18.0 for Bristol Bay red king crab.



Summary

1) In 2018, the survey biomass decreases about 50% from 2017, more than expected. The disappointment is very low estimated recruitments, which are among the lowest since 1973.
2) Model estimated relative survey biomasses are similar among the six scenarios and fit the survey data reasonably well. The absolute mature male biomass estimates are extremely close among scenarios 18.0, 18.0a, 18.0b and 18.0c and higher than for scenarios 2b and 2b-old during recent years.
3) Recruitment estimates in terminal years are highly uncertain, and uncertainties of recruitment estimates decrease sharply from one year estimated in the model to two or more years in the model.
4) Estimated B_0 values change greatly over time; however, without an S-R model and quantified environmental effects, estimated B_0 values do not provide much valuable information.

Recommendations

1) Scenario 18.0 or 18.0a is recommended for overfishing determination this year, because the results are hardly different among scenarios 18.0, 18.0a, 18.0b and 18.0c and these two scenarios have the least number of estimated parameters.
2) Scenario 2b will be discontinued next year due to changes in data collection.
3) Recruitment in terminal year should not be used for estimating $B_{35\%}$. That is, mean recruitment is estimated from recruitments from 1984 to endyear – 1.

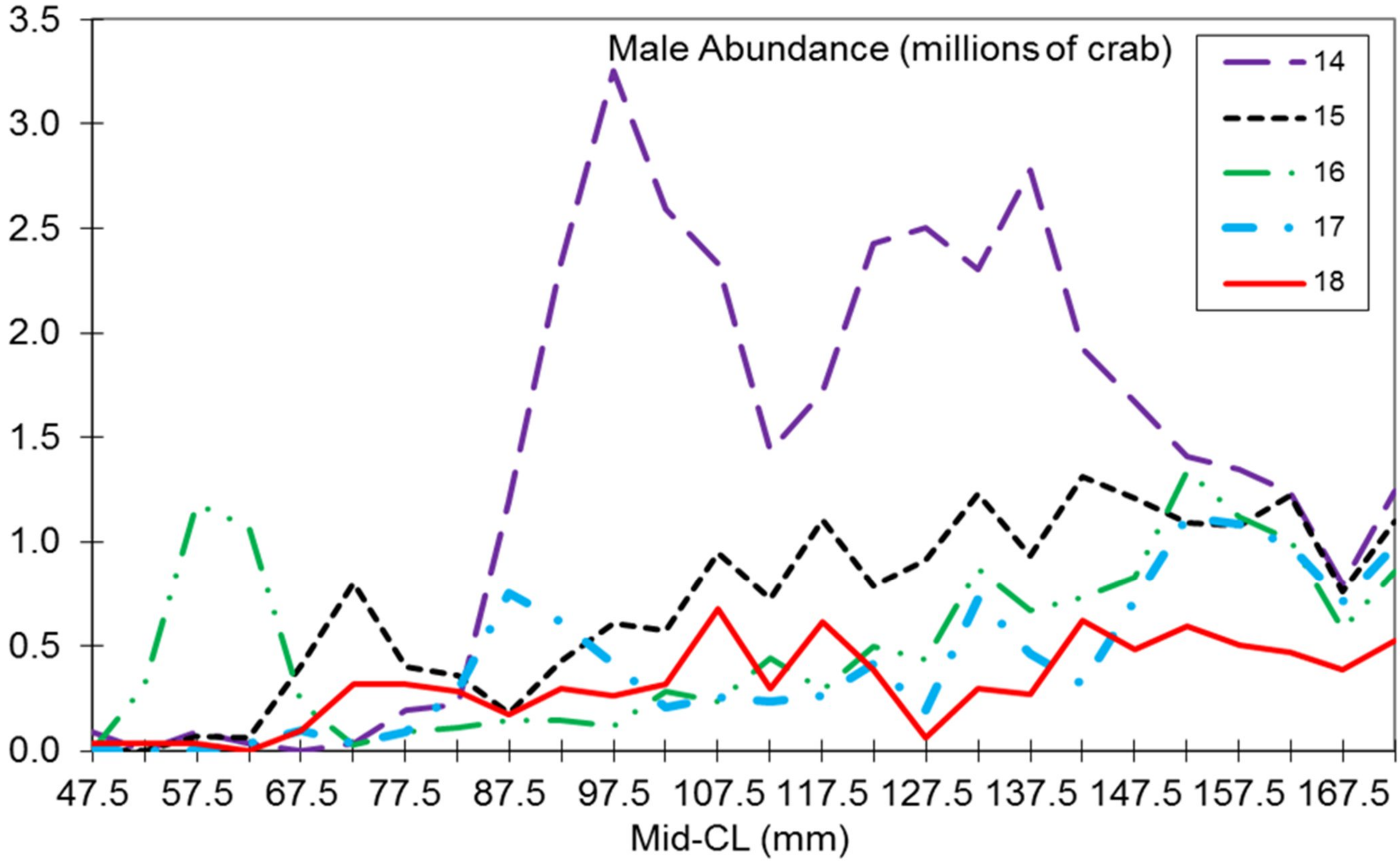
Status and catch specifications in 1000 t (scenario 18.0):

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2014/15	13.03[A]	27.25[A]	4.49	4.54	5.41	6.82	6.14
2015/16	12.89[B]	27.68[B]	4.52	4.61	5.31	6.73	6.06
2016/17	12.53[C]	25.81[C]	3.84	3.92	4.35	6.64	5.97
2017/18	12.77[D]	24.53[D]	2.99	3.09	3.48	5.60	5.04
2018/19		20.62[D]				5.21	4.69

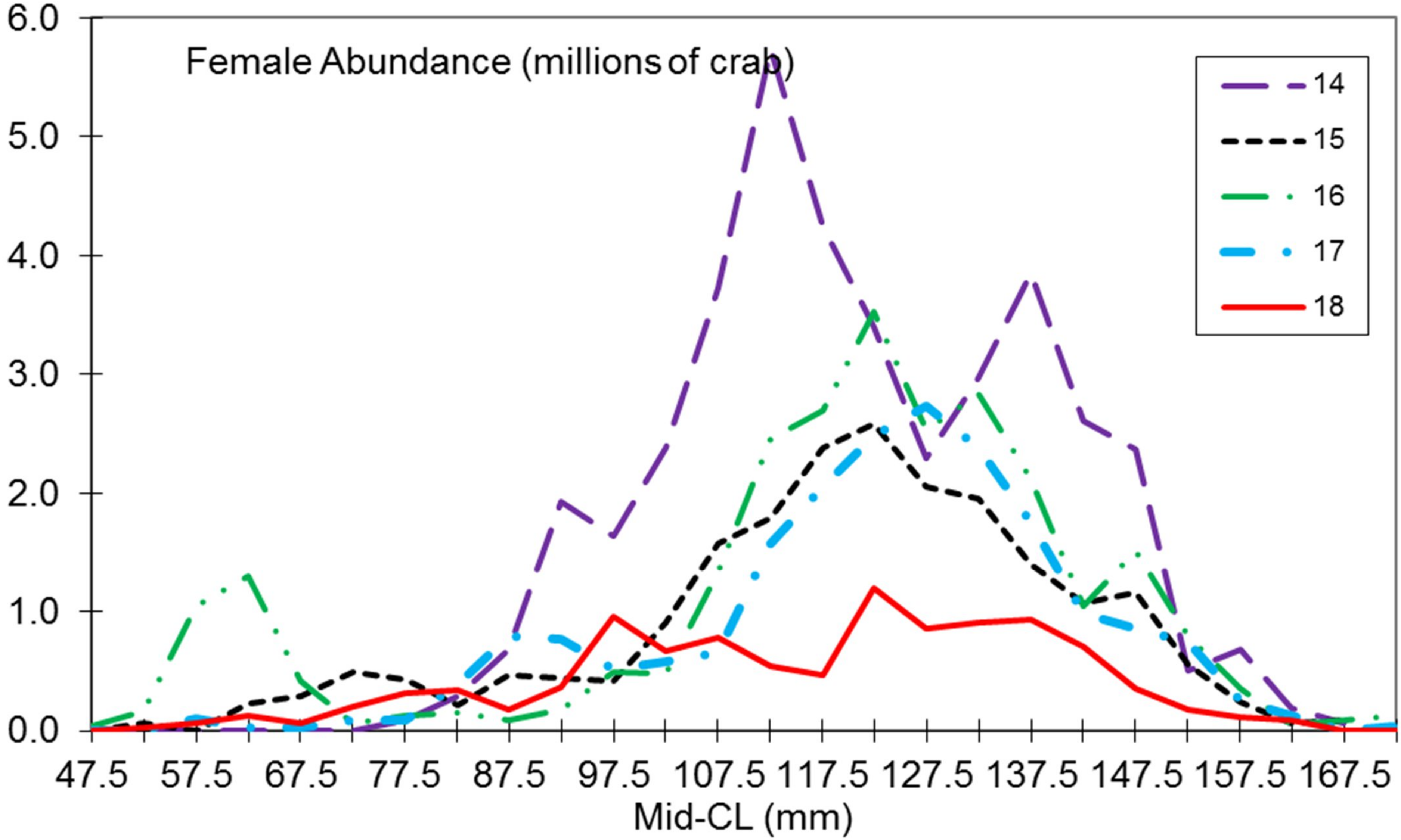
6. Basis for the OFL: All table values are in 1000 t (Scenario 18.0):

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
2014/15	3b	25.7	24.7	0.96	0.28	1984-2014	0.18
2015/16	3b	26.1	24.7	0.95	0.27	1984-2015	0.18
2016/17	3b	25.8	24.0	0.93	0.27	1984-2016	0.18
2017/18	3b	25.1	21.3	0.85	0.24	1984-2017	0.18
2018/19	3b	25.5	20.6	0.81	0.24	1984-2017	0.18

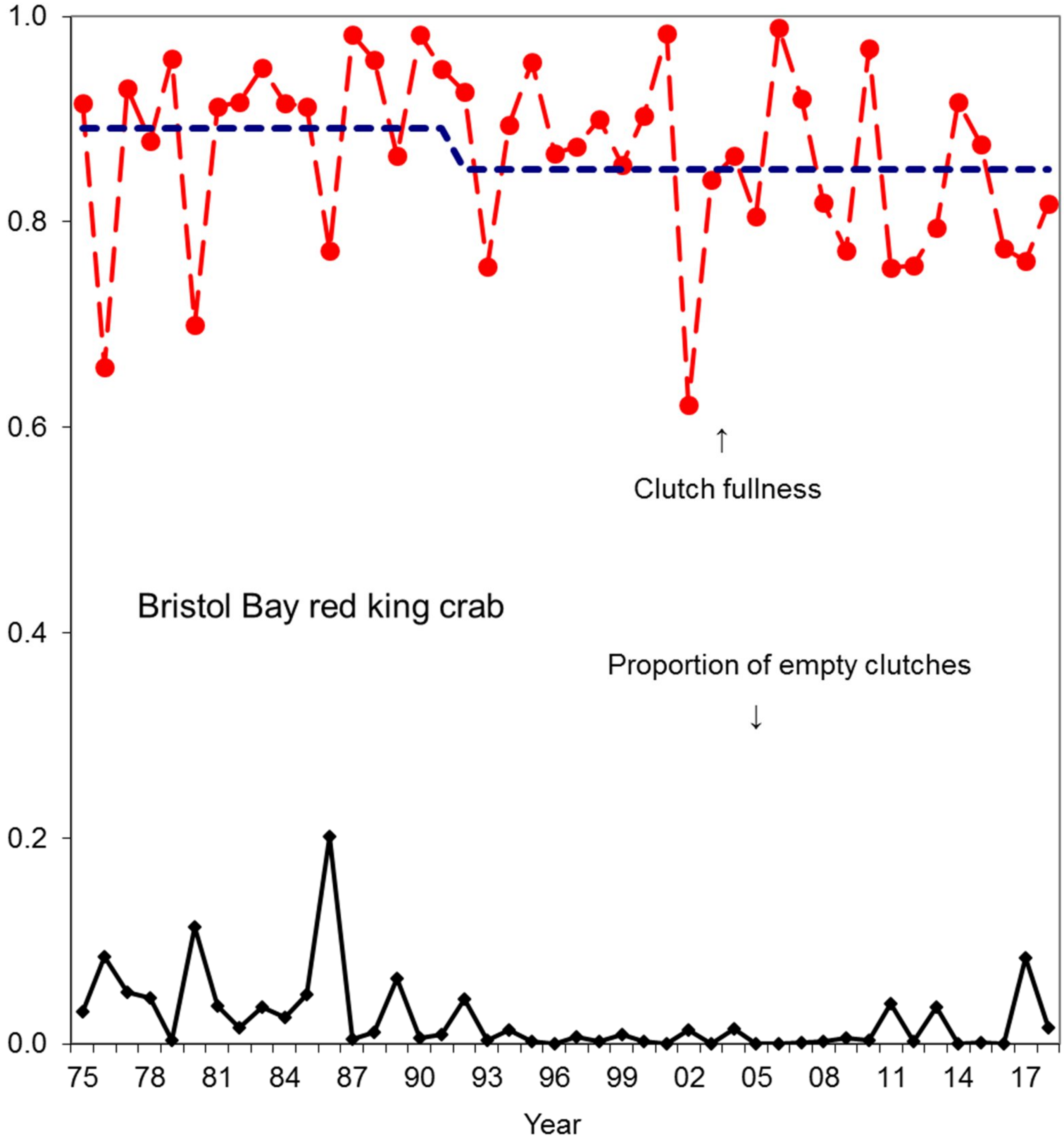
Male area-swept abundance during 2014-2018



Female area-swept abundance during 2014-2018



Thanks



Clutch fullness fluctuated over time.