Bristol Bay Red King Crab Assessment in Fall 2017

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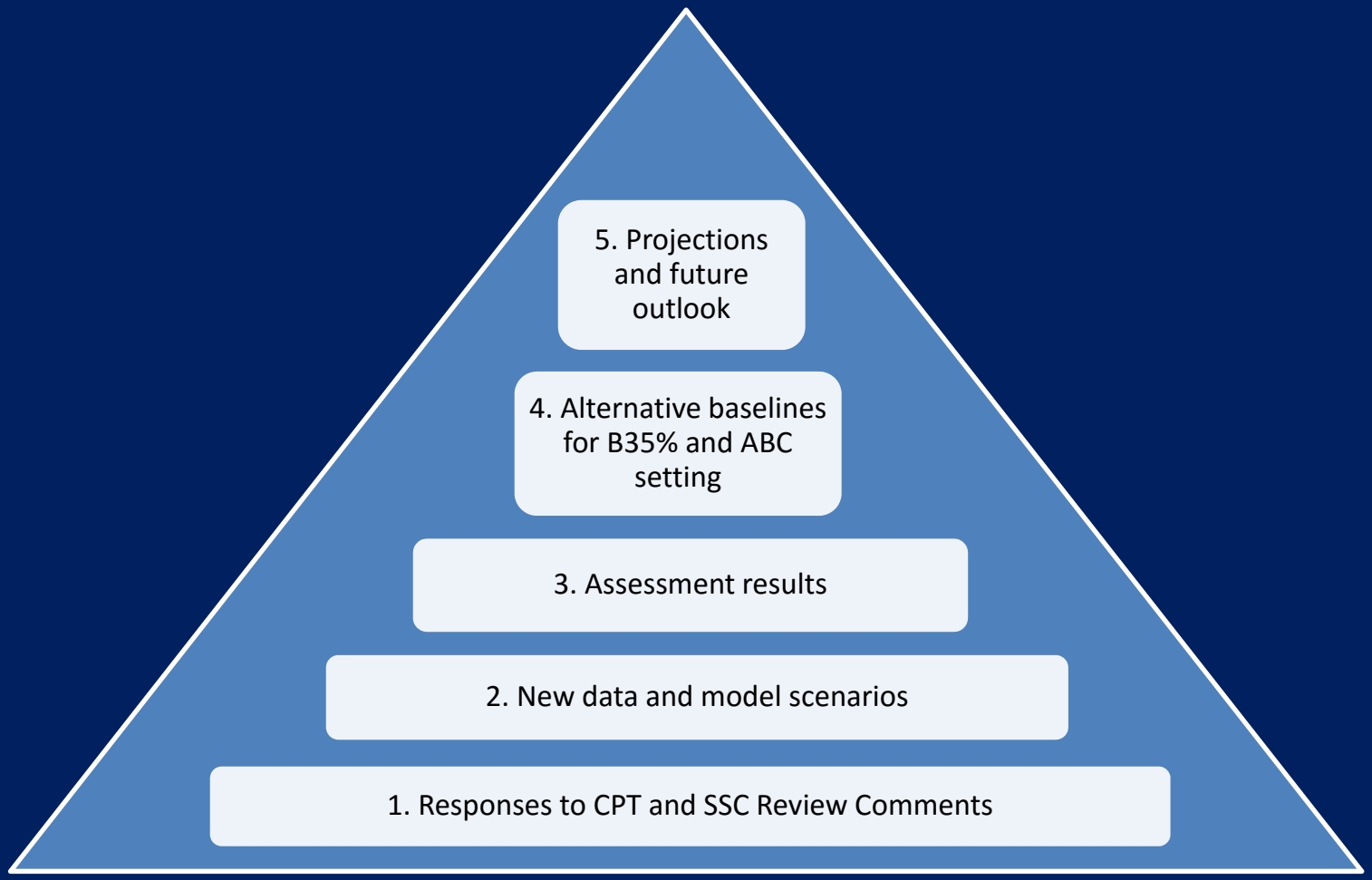
ADF&G, Juneau

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 2016):

"The CTP requests that model runs be provided to evaluate the impact of including or excluding the prior on catchability based on the under-bag experiment."

Response: three scenarios in May 2017 addressed this comment.

Response to CPT Comments

Response to CPT Comments (from May 2017):

"The CPT recommended the following scenarios be evaluated for the Fall 2017 assessment:

- *Scenario 2a*
- *Scenario 2b*
- *Scenario 2d*

In addition, because the discard biomass time series from the groundfish fixed and trawl gear fisheries are not split by sex, these models should be brought forward using two approaches to Francis (2011) re-weighting of the size compositions: one based on weights calculated as if all the size compositions were sex-specific, and one based on weights calculated from the "extended" size compositions used in the models for the groundfish fixed gear and trawl gear bycatch size compositions. The former approach is based on the expectation of sex-specific changes in mean length, but does not reflect the loss of sex ratio information associated with splitting the size compositions by sex, whereas the latter approach incorporates this information while the weights are based on expectations for changes in size class across the "extended" size composition."

Response: All nine scenarios in the SAFE report in September 2017 address this comment.

Response to SSC Comments

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

"Five model scenarios were investigated prior to the spring CPT meeting, the results of which suggested relatively minor differences with regard to management quantities. The SSC supports the CPT's and author's recommendations regarding model scenarios to bring forward this fall, which include the following: add the 2016 BSFRF data, separate bycatch components, remove the informative prior and reparameterize NMFS survey catchability to exclude values greater than 1.0, as well as alternatives for data weighting within these scenarios."

Response: All nine scenarios in the SAFE report in September 2017 address this comment.

Response to SSC Comments

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

"The SSC noted that only scenarios utilizing Francis weighting methods were proposed for evaluation in the fall. As noted earlier regarding general guidance to the CPT and assessment authors, the SSC encourages stock assessment authors and the CPT to continue to consider alternative approaches, as data weighting is not a 'one-size-fits-all' problem. The best method for data weighting will depend on the quality of the data, the time-series length, the conflict among data sources and other factors unique to a specific assessment. Thus, the BBRKC stock assessment author should retain sufficient latitude to use a method appropriate for this particular assessment, noting that internal consistency is more important than blanket consistency across assessments dealing with a variety of unique data configurations and estimation issues. Evaluation of alternative data weighting approaches can be a useful diagnostic tool to better understand conflicts among data sources within the BBRKC assessment."

Response: Authors wholeheartedly agree with this SSC comment. We used Francis' approach in this report and were a little struggled to get scenarios converged. The effective sample sizes are greatly reduced through Francis' approach. We will search for alternative approaches in the future.

Response to SSC Comments

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

"TAlso, the SSC encourages the BBRKC author to objectively define the terminal year of recruitment to include in reference point calculations in this assessment. For BBRKC, where all recent recruitment years have been used in the past, dropping one or more years at the end of the time-series might be warranted. A general rule could be based on the variance of the estimated recruitments and/or the youngest ages of crabs sampled by the fishing gear and/or survey gear included in the model."

Response: This is a very good suggestion. We did not make any changes for this report due to many scenarios and will evaluate this in May 2018.

Summary of Major Changes in 2017

1. Changes to the input data:
   a. The new 2017 NMFS trawl survey data.
   b. Updating BSFRF side-by-side trawl survey data in 2016. Total survey biomass decreased from 87725.1 t initially estimated in September 2016 to 77815.7 t in the final estimate, about 11.3% reduction.
   c. Catch and bycatch data were updated with 2017 data.

Summary of Major Changes in 2017

2. Changes to the assessment methodology:

a. Francis' approaches for re-weighting effective sample sizes for size composition data are applied for some scenarios and are detailed in Appendix C.

For Bristol Bay red king crab, length composition values are computed with both sexes combined for survey and groundfish fisheries bycatch data. Mean lengths can be computed with two approaches:

(1). Both male and female length compositions are stacked into a vector and used to compute a mean length for both sexes for each of survey and groundfish fisheries bycatch datasets.

(2). Sex-specific length compositions are normalized so that the sum is equal to 1.0 for each sex for each of survey and groundfish fisheries bycatch datasets. The normalized length compositions are used to estimate mean lengths.

b. Nine Model Scenarios

2a. The same as 2a in May 2017 and slightly revised scenario 2 in 2016 with updated data and changing the fishing time of the groundfish fisheries bycatch to mid-point of crab year to more accurately reflect the fishing timing.

2b. The same as scenario 2a except with separating groundfish fisheries bycatch by trawl fisheries and fixed gear fisheries.

2d. The same as scenario 2b except without trawl survey catchability prior from the double-bag experiment and with using a logit transformation to make sure trawl survey catchability be <1.0:

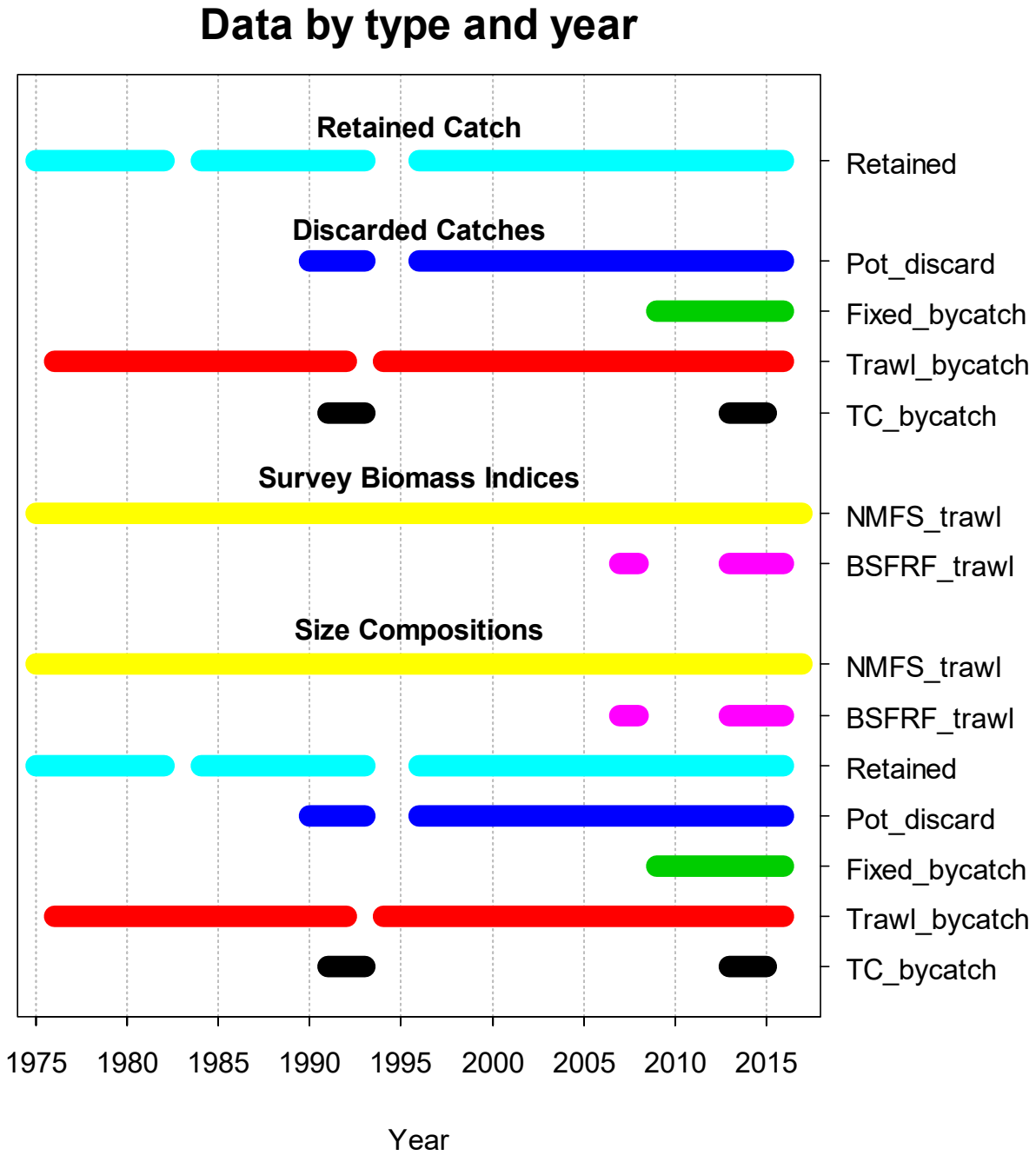
$$Q = \exp(x)/(1+\exp(x)),$$

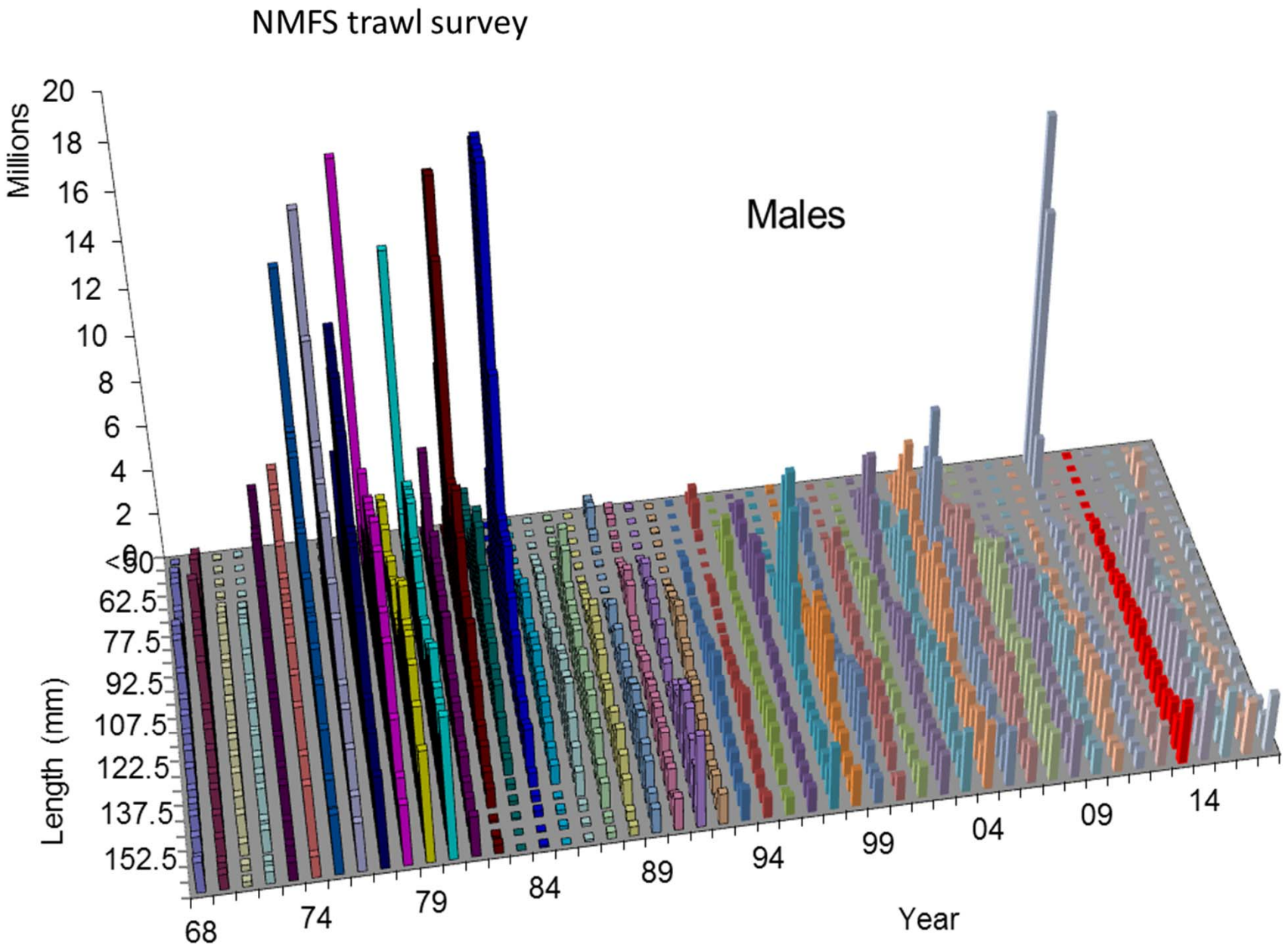
where *x* is estimated as a parameter.

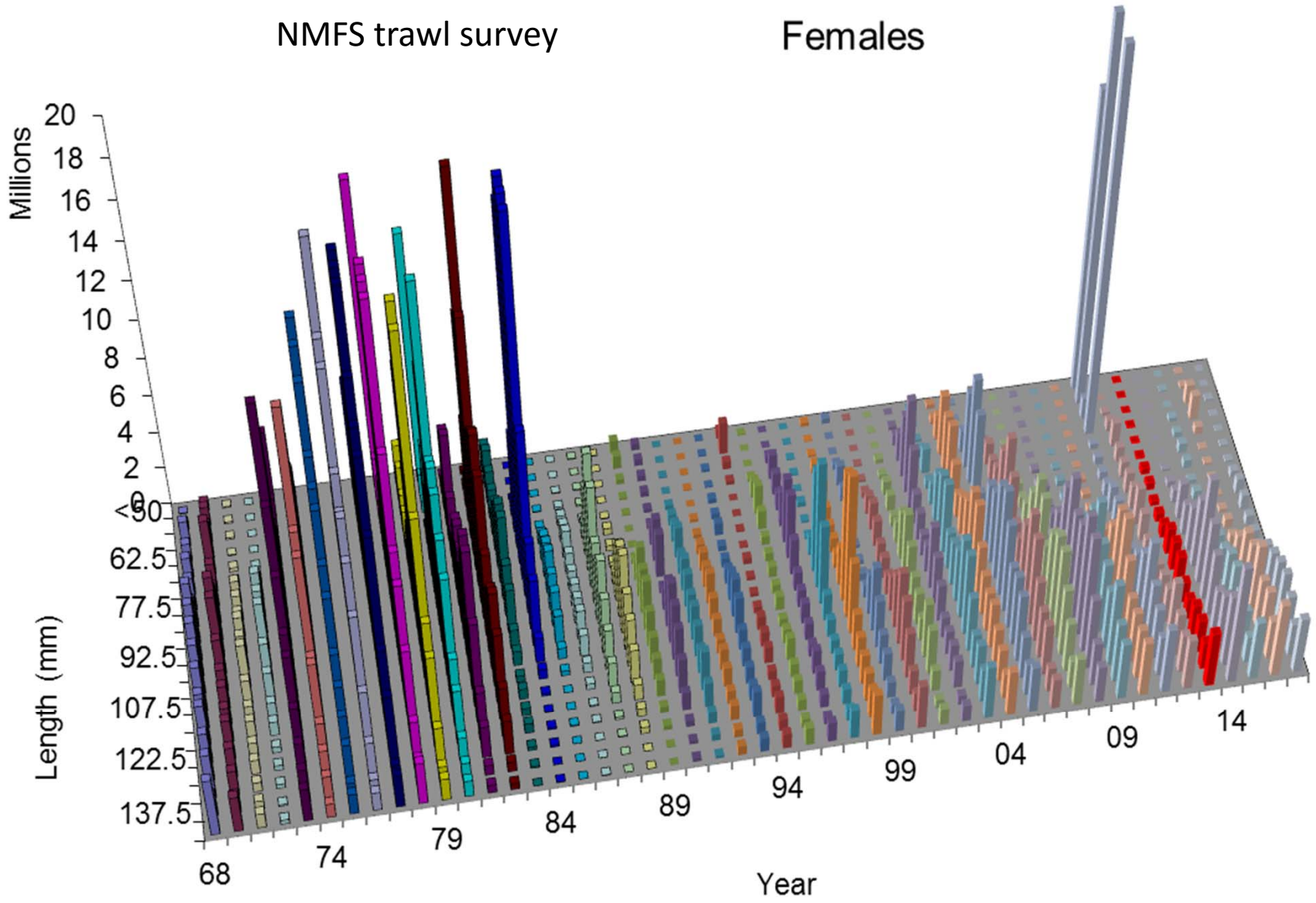
2a1, 2a2. Scenario 2a with Francis' two approaches.

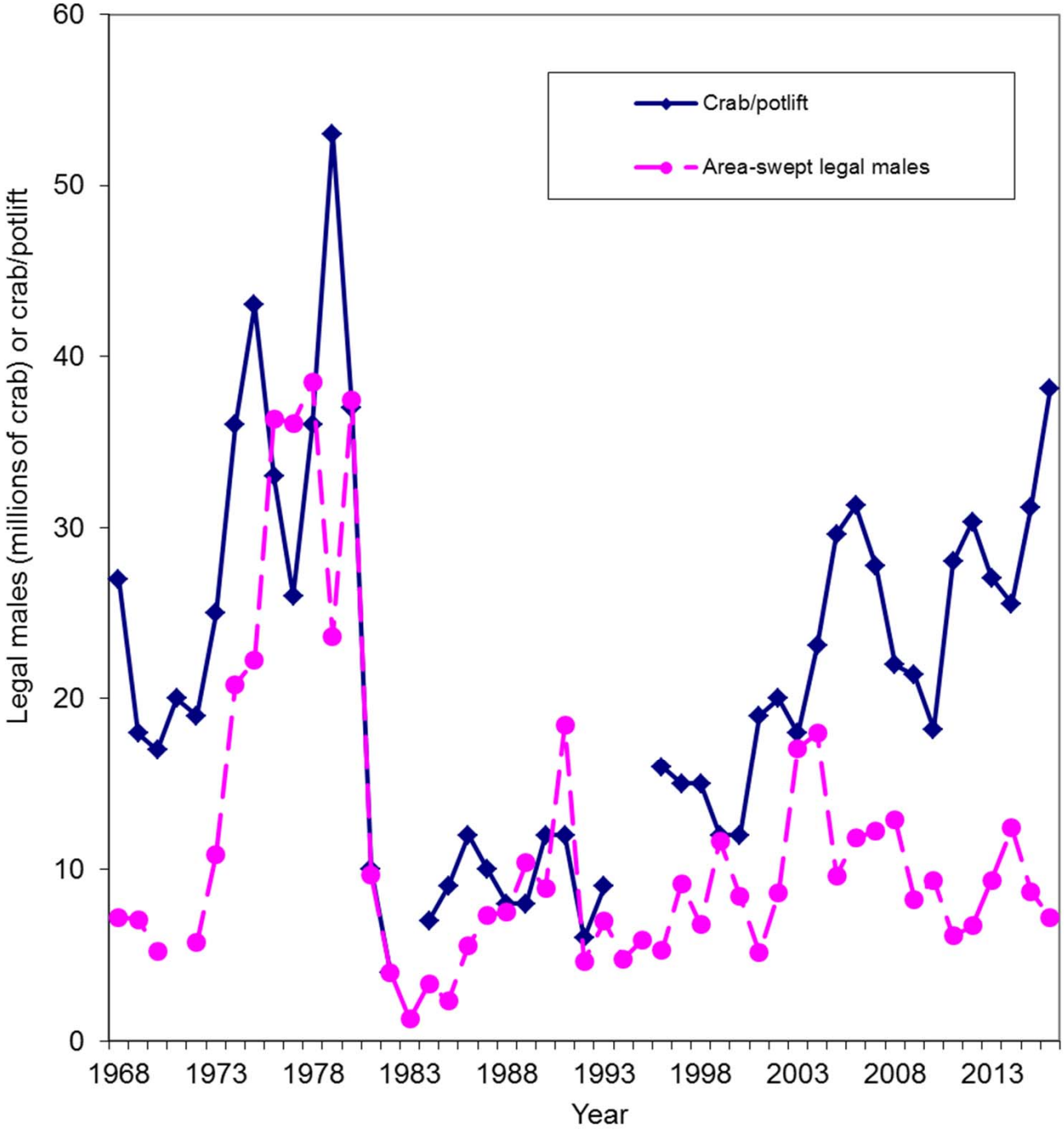
2b1, 2b2. Scenario 2b with Francis' two approaches.

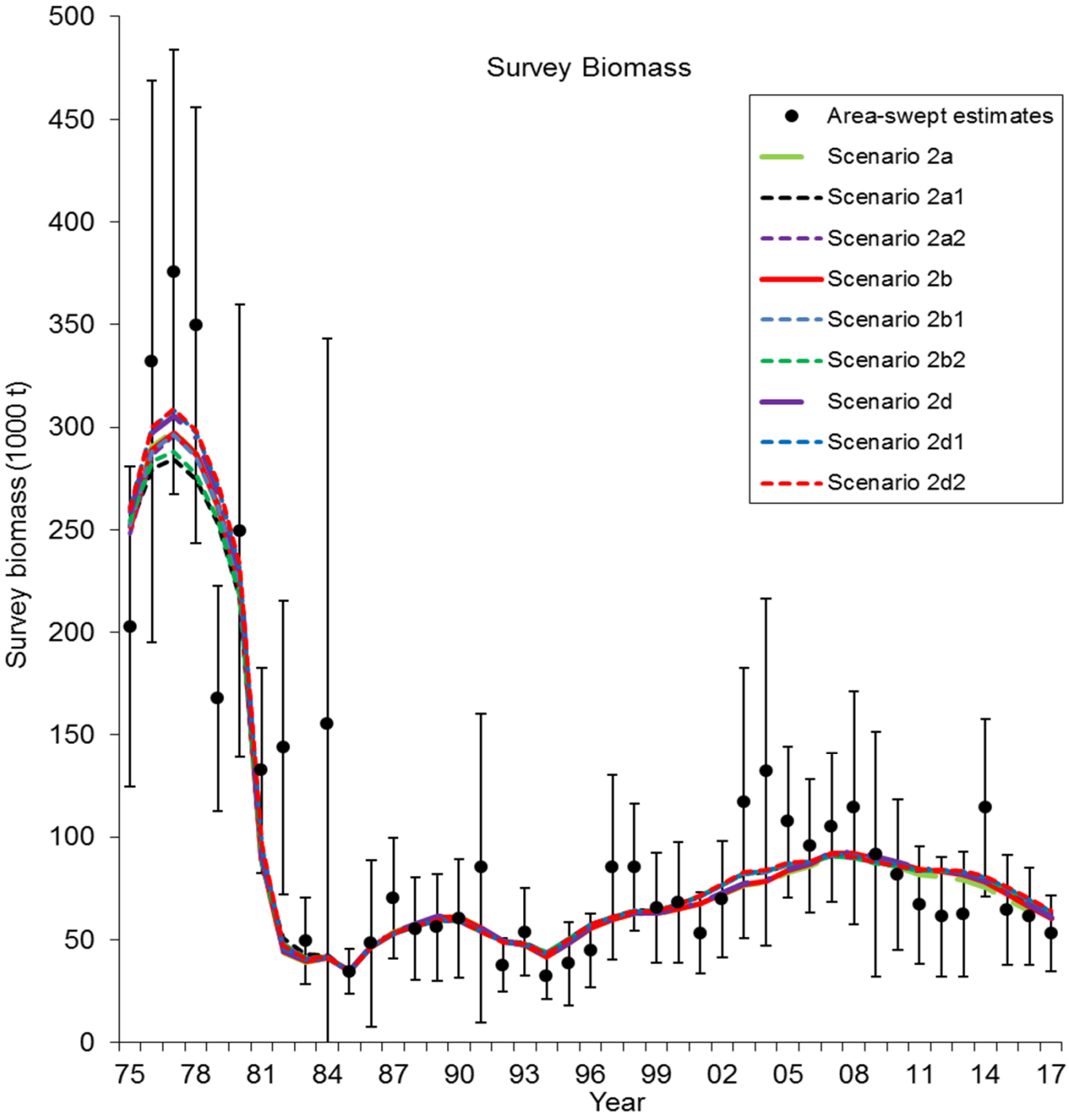
2d1, 2d2. Scenario 2d with Francis' two approaches.

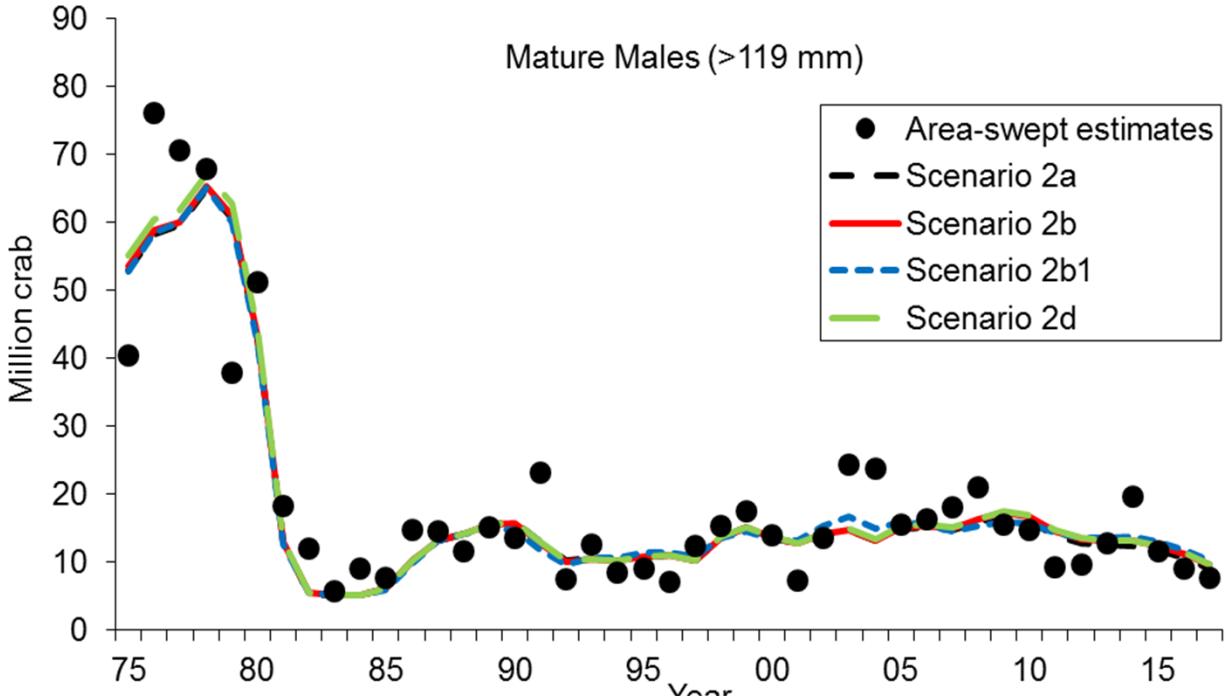

Data by type and year
Retained Catch
Retained
Discarded Catches
Pot_discard
Fixed_bycatch
Trawl_bycatch
TC_bycatch
Survey Biomass Indices
NMFS_trawl
BSFRF_trawl
Size Compositions
NMFS_trawl
BSFRF_trawl
Retained
Pot_discard
Fixed_bycatch
Trawl_bycatch
TC_bycatch
1975
1980
1985
1990
1995
2000
2005
2010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

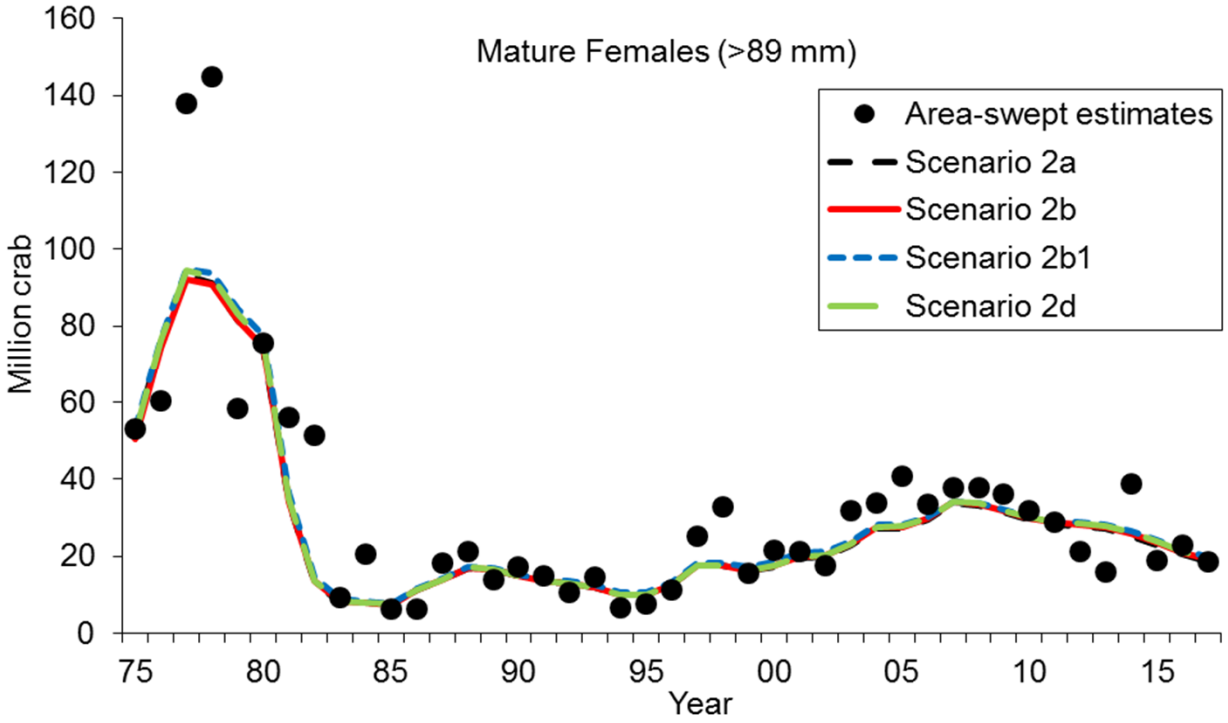

NMFS trawl survey
Males
Millions
20
18
16
14
12
10
8
6
4
2
0
Length (mm)
<60
62.5
77.5
92.5
107.5
122.5
137.5
152.5
68
74
79
84
89
94
99
04
09
14
Year

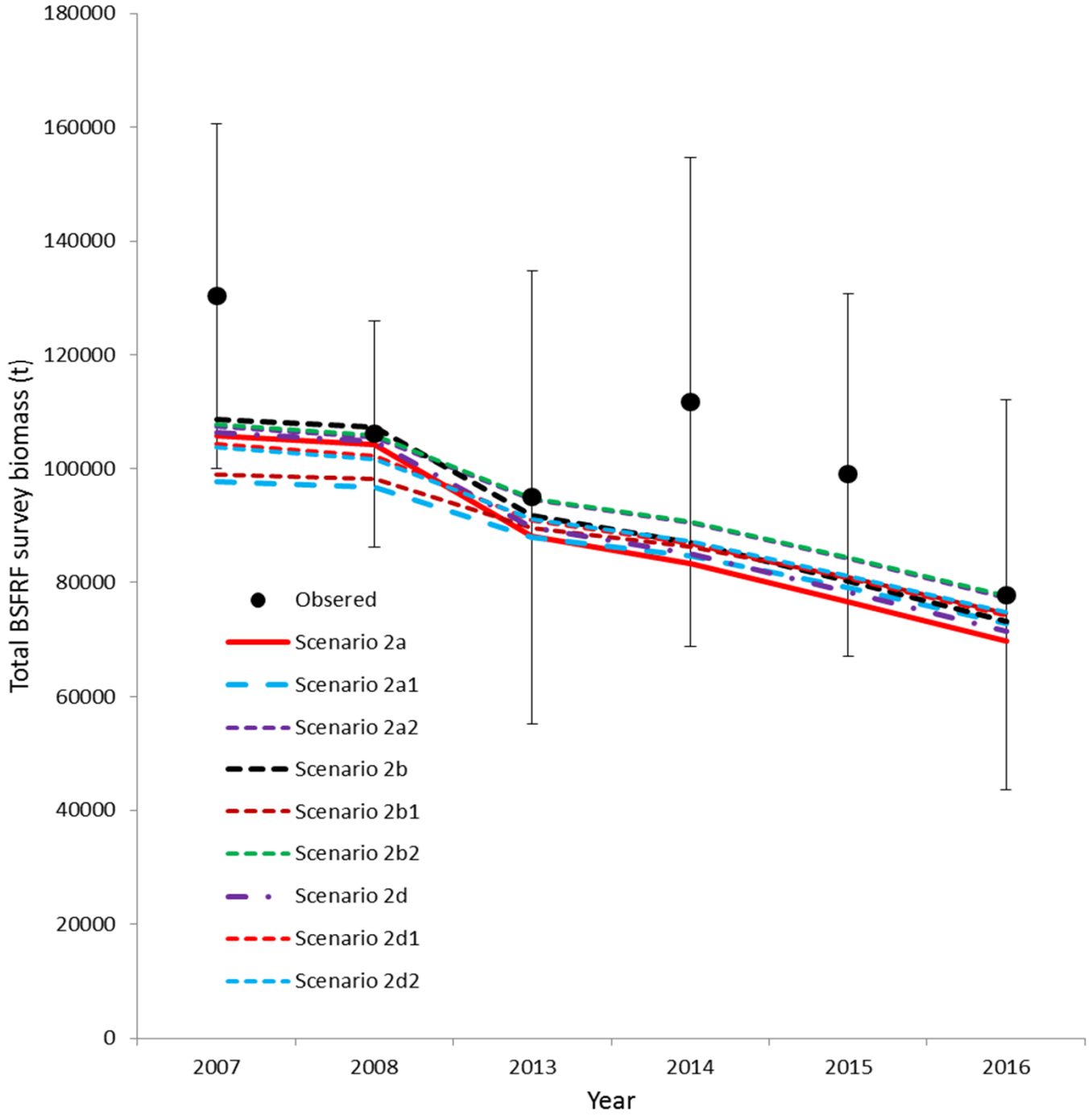

NMFS trawl survey
Females
Millions
20
18
16
14
12
10
8
6
4
2
0
Length (mm)
<50
62.5
77.5
92.5
107.5
122.5
137.5
68
74
79
84
89
94
99
04
09
14
Year

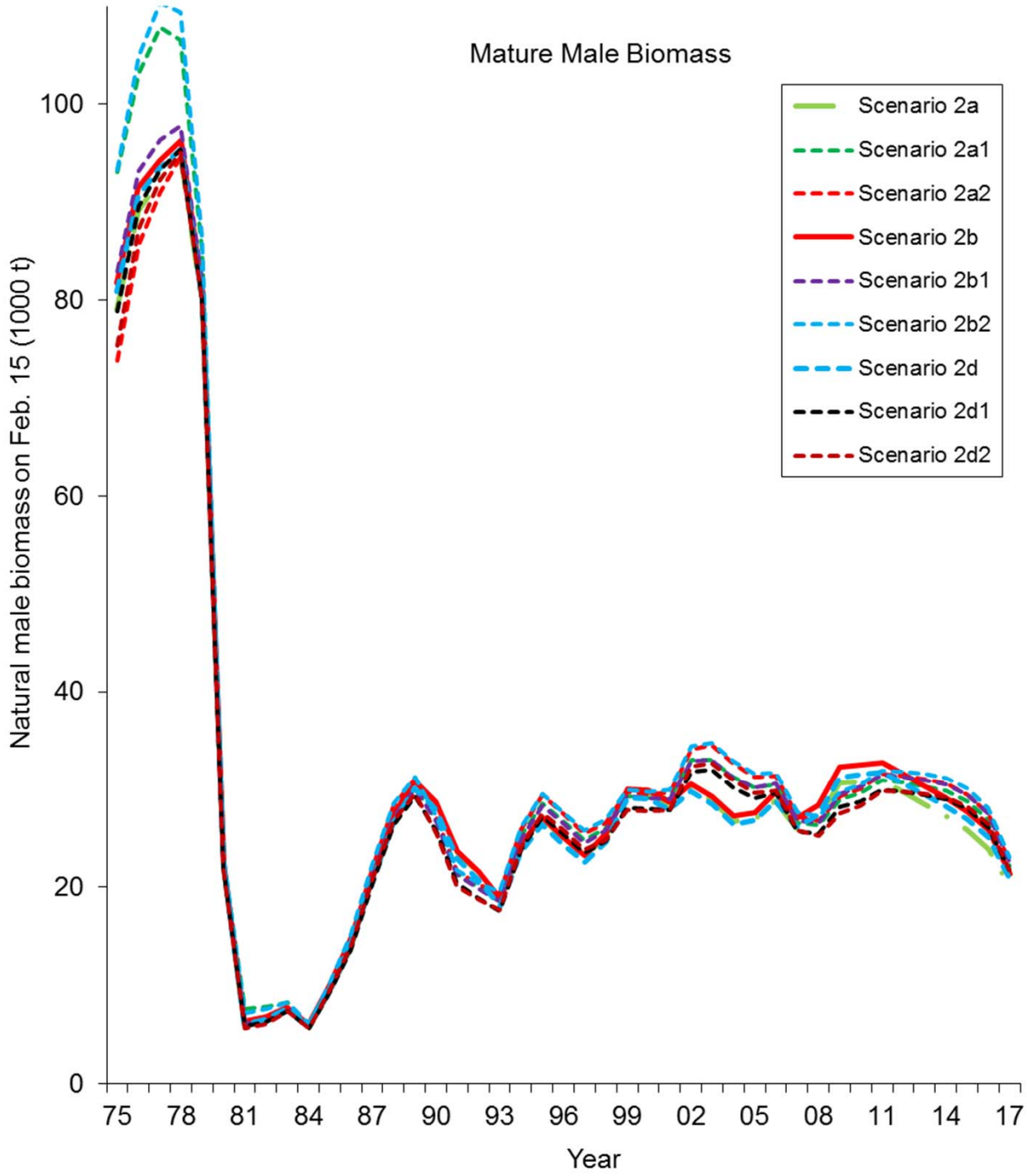

Crab/potlift
Area-swept legal males
Legal males (millions of crab) or crab/potlift
Year
0
10
20
30
40
50
60
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013


Survey Biomass
Area-swept estimates
Scenario 2a
Scenario 2a1
Scenario 2a2
Scenario 2b
Scenario 2b1
Scenario 2b2
Scenario 2d
Scenario 2d1
Scenario 2d2
Survey biomass (1000 t)
0
50
100
150
200
250
300
350
400
450
500
75
78
81
84
87
90
93
96
99
02
05
08
11
14
17
Year


Mature Males (>119 mm)
Area-swept estimates
Scenario 2a
Scenario 2b
Scenario 2b1
Scenario 2d
Million crab
0
10
20
30
40
50
60
70
80
90
75
80
85
90
95
00
05
10
15

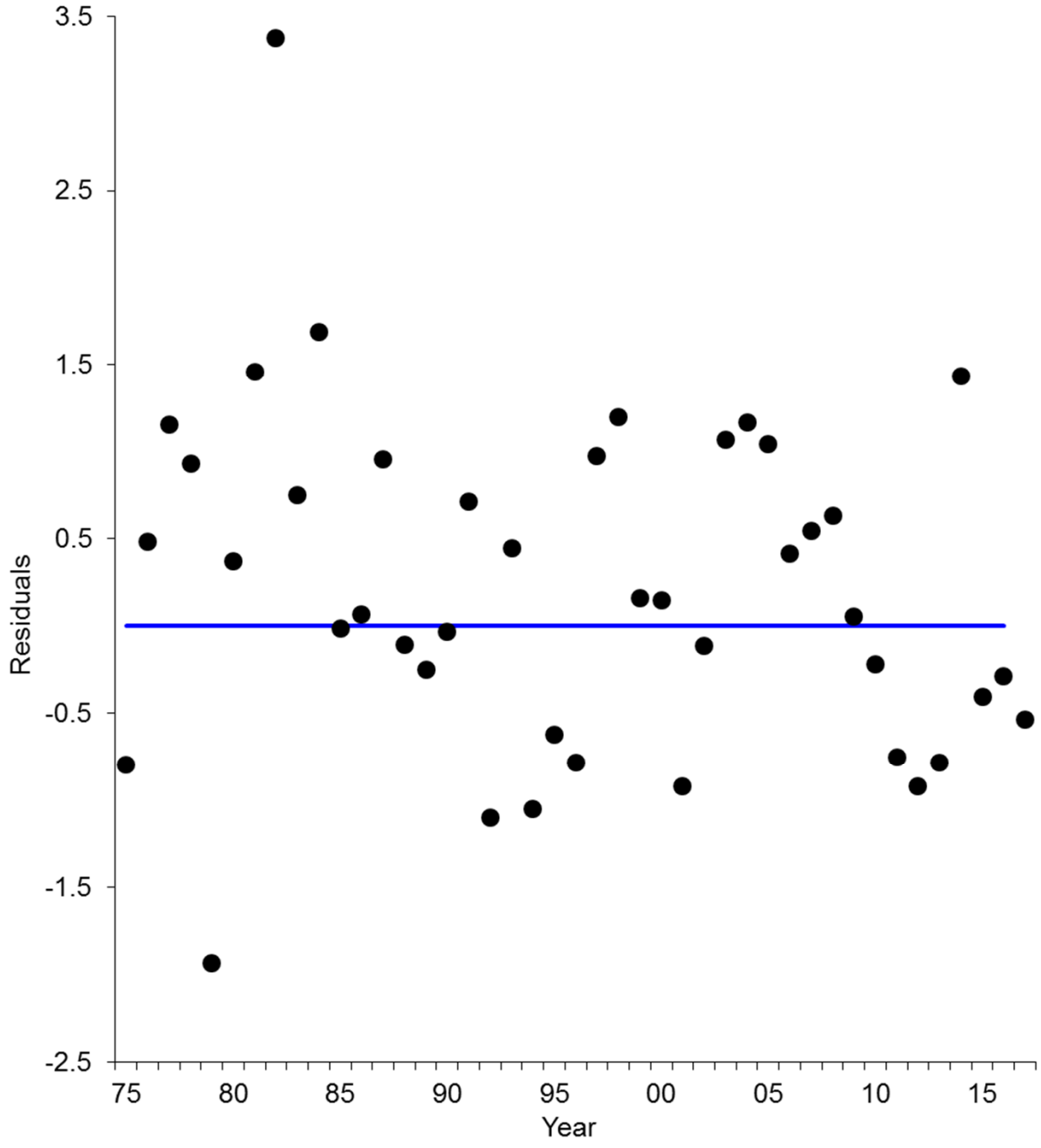

Mature Females (>89 mm)
Area-swept estimates
Scenario 2a
Scenario 2b
Scenario 2b1
Scenario 2d
Million crab
0
20
40
60
80
100
120
140
160
75
80
85
90
95
00
05
10
15
Year


180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Total BSFRF survey biomass (t)
2007
2008
2013
2014
2015
2016
Year
Obsered
Scenario 2a
Scenario 2a1
Scenario 2a2
Scenario 2b
Scenario 2b1
Scenario 2b2
Scenario 2d
Scenario 2d1
Scenario 2d2

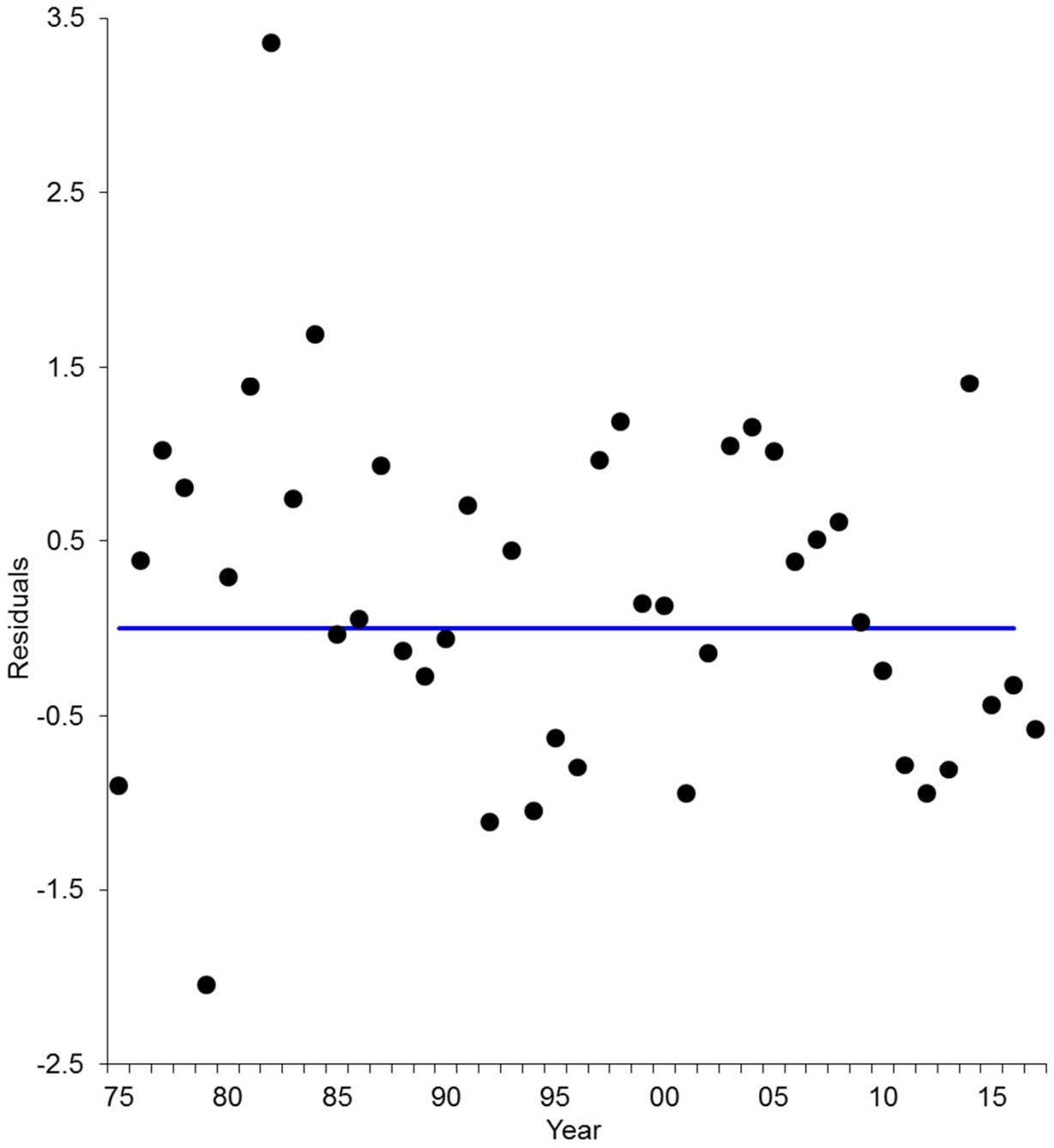

Mature Male Biomass
Natural male biomass on Feb. 15 (1000 t)
Year
0
20
40
60
80
100
75
78
81
84
87
90
93
96
99
02
05
08
11
14
17
Scenario 2a
Scenario 2a1
Scenario 2a2
Scenario 2b
Scenario 2b1
Scenario 2b2
Scenario 2d
Scenario 2d1
Scenario 2d2

Scenario									
Negative log likelihood	2a	2a1	2a2	2b	2b1	2b2	2d	2d1	2d2
R-variation	87.37	68.19	63.71	87.22	66.69	62.99	87.21	66.22	62.89
Length-like-retained	-1038.8	-854.8	-904.2	-1038.9	-893.7	-895.3	-1039.3	-898.2	-906.3
Length-like-discmale	-1092.0	-832.2	-825.1	-1092.4	-828.8	-822.5	-1092.1	-831.7	-824.2
Length-like-discfemale	-567.31	-567.31	-567.53	-795.01	-567.94	-567.92	-794.89	-567.41	-567.57
Length-like-survey	-48633	-39299	-37689	-48629	-39307	-37656	-48631	-39293	-37687
Length-like-disctrawl	-4107.3	-2552.5	-2315.8	-3784.5	-2912.2	-2629.8	-3784.4	-2908.3	-2615.6
Length-like-discfix	0.00	0.00	0.00	-773.41	-474.42	-477.78	-773.36	-473.35	-478.20
Length-like-discTanner	-466.54	-360.23	-359.95	-467.04	-361.86	-360.08	-467.31	-362.31	-360.48
Length-like-bsfrfsurvey	-644.79	-559.96	-533.44	-645.73	-561.12	-535.16	-645.92	-565.08	-535.70
Catchbio_retained	50.95	27.96	25.27	51.13	28.30	25.48	51.32	28.21	25.28
Catchbio_discmale	228.10	140.60	127.97	229.35	142.25	128.05	229.15	142.07	128.16
Catchbio-discfemale	0.11	0.05	0.04	0.11	0.04	0.04	0.11	0.04	0.04
Catchbio-disctrawl	0.22	0.02	0.01	0.22	0.02	0.02	0.22	0.02	0.02
Catchbio-discfix	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Catchbio-discTanner	0.12	0.01	0.00	0.13	0.01	0.01	0.14	0.01	0.00
Biomass-trawl survey	103.86	98.27	98.81	103.70	99.61	100.54	102.61	99.56	98.51
Biomass-bsfrfsurvey	-7.88	-7.52	-8.25	-8.29	-7.69	-8.38	-8.14	-8.08	-8.09
Q-trawl survey	4.86	1.86	1.52	3.84	1.31	2.08	0.00	0.00	0.00
Others	16.57	16.61	16.79	18.05	18.12	18.05	18.02	18.23	18.12
Total	-56066	-44680	-42869	-56740	-45558	-43616	-56748	-45553	-43651
Free parameters	281	281	281	292	292	292	292	292	292
B35%(t)	24613	25641	25853	25050	25664	26150	24744	25386	25349
F35%	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
MMB2017(t)	20043	22181	22629	21312	22642	23090	20814	21758	21924
OFL2017	5012.3	5991.2	6212.4	5599.7	6261.1	6326.4	5393.6	5773.7	5894.3
ABC2017(t)	4511.1	5392.0	5591.2	5039.7	5635.0	5693.8	4854.2	5196.3	5304.9
Fofl2017	0.23	0.25	0.25	0.24	0.25	0.25	0.24	0.24	0.25
Q82-17	0.97	0.94	0.94	0.97	0.94	0.95	1.00	1.00	1.00

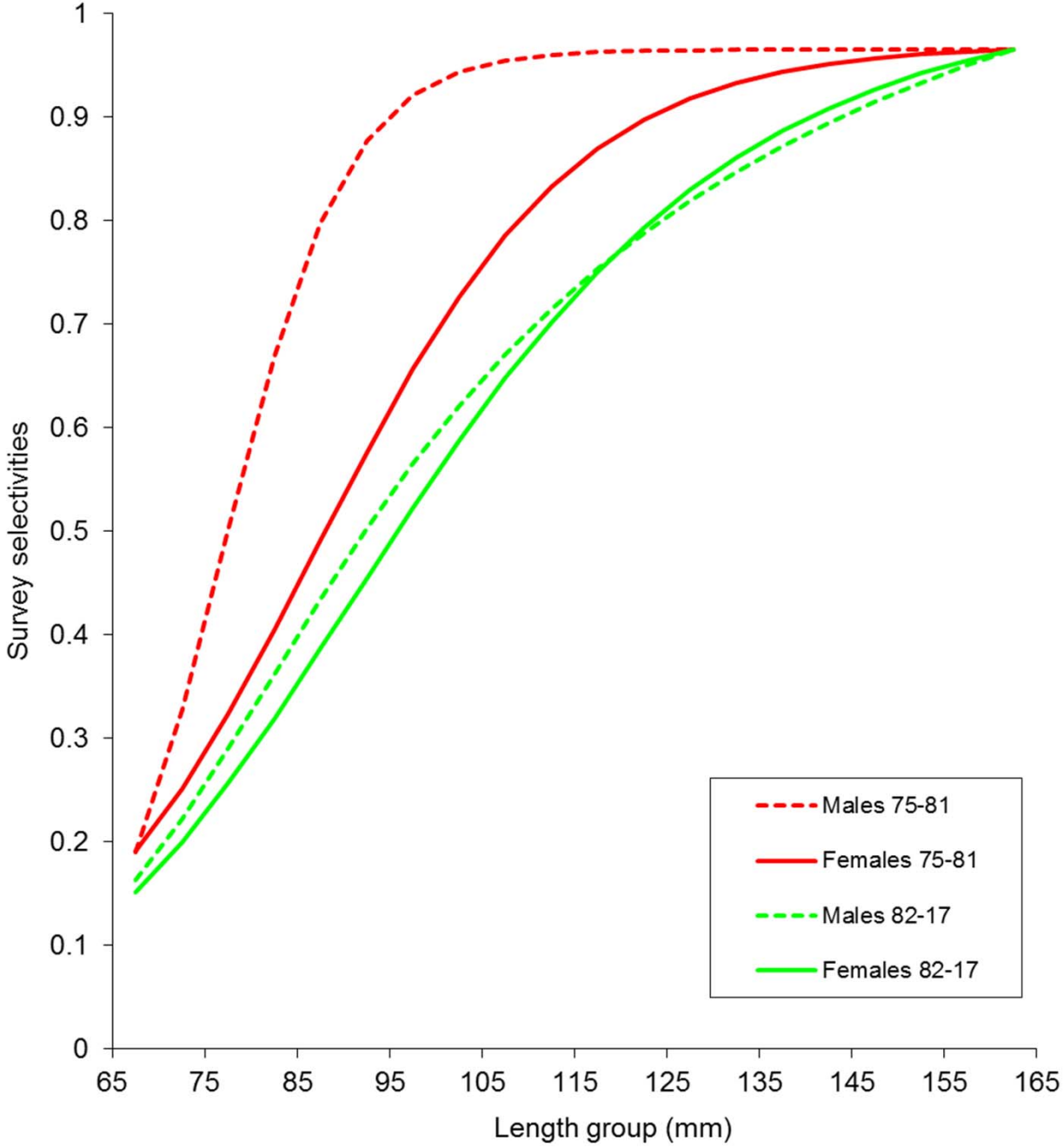
- ✓ In 2017, the survey mature male abundance is slightly less than expected while survey female abundance is as expected based on the survey abundances during the previous several years. The disappointment is very low estimated recruitments, which are among the lowest since 1973.
- ✓ Model estimated relative survey biomasses are very similar among the nine scenarios and fit the survey data reasonably well. The absolute population biomass estimates are higher for Scenarios 2a1 and 2b2 during mid and late 1970s than other scenarios, likely due to estimated higher proportions of males in initial year 1975. Estimated biomass variations among scenarios during recent 15 years are likely caused by the different weights on BSFRF survey length composition data.
- ✓ Francis' re-weighting approaches greatly reduce effective sample sizes and make it difficult for estimation to converge.
- ✓ Scenario 2b or 2d is recommended for overfishing determination this year.



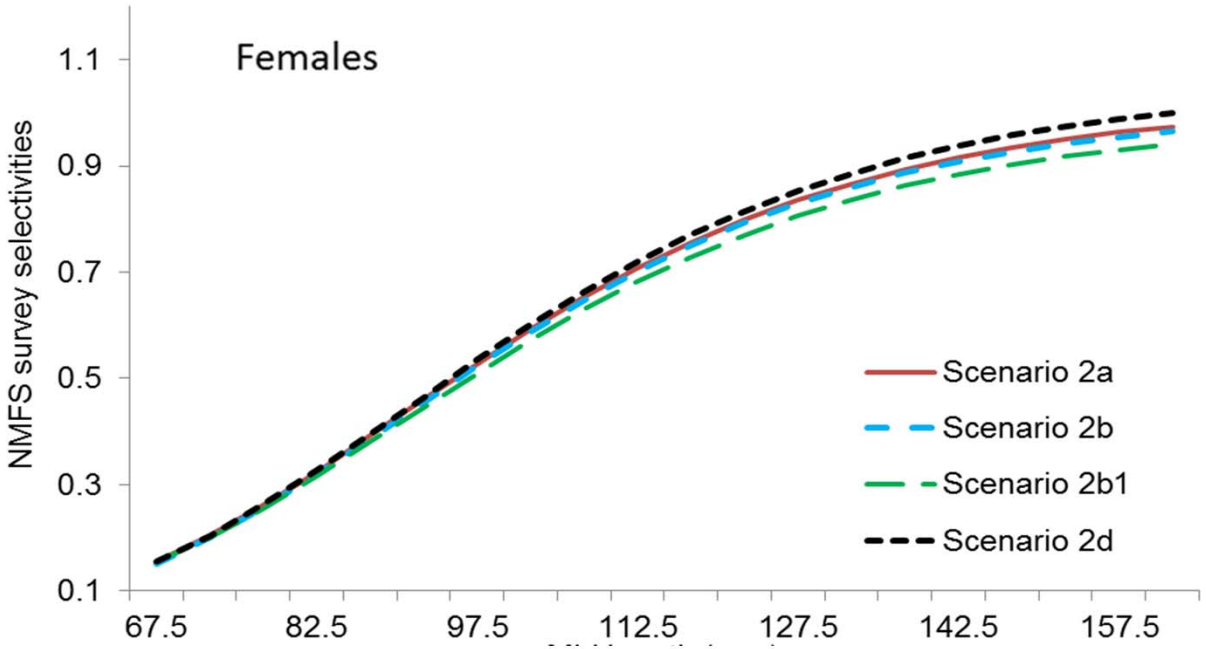
Standardized residuals of total NMFS survey biomass. Scenario 2b



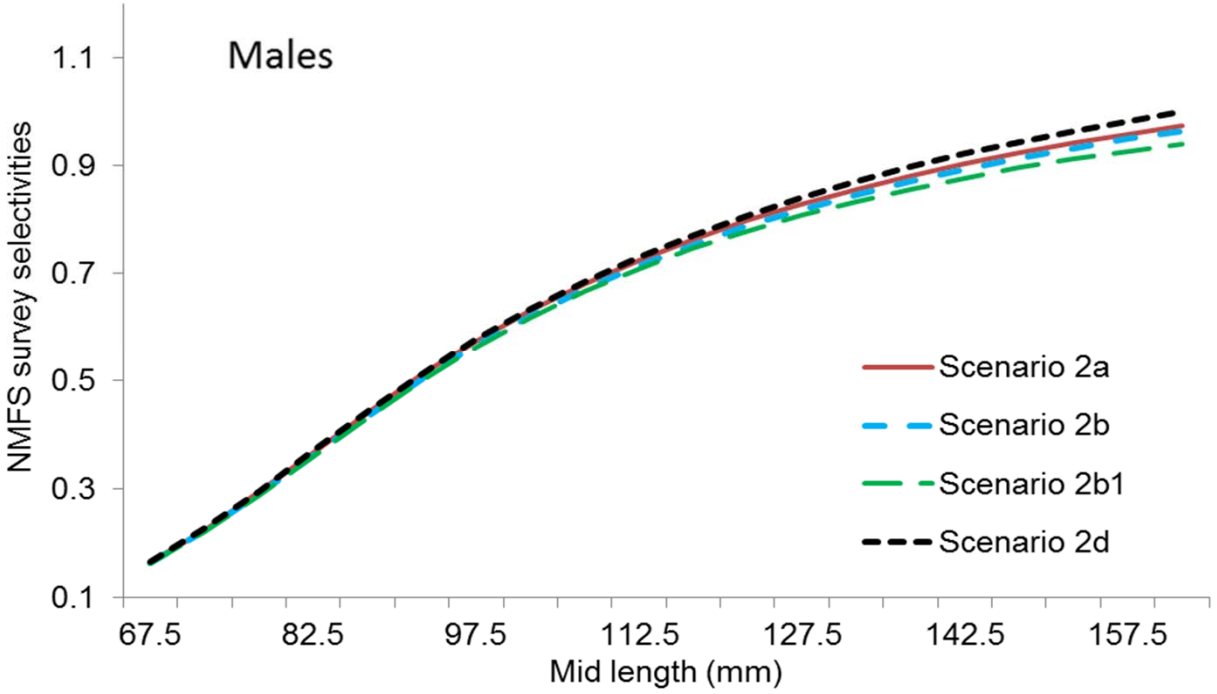
Standardized residuals of total NMFS survey biomass. Scenario 2d

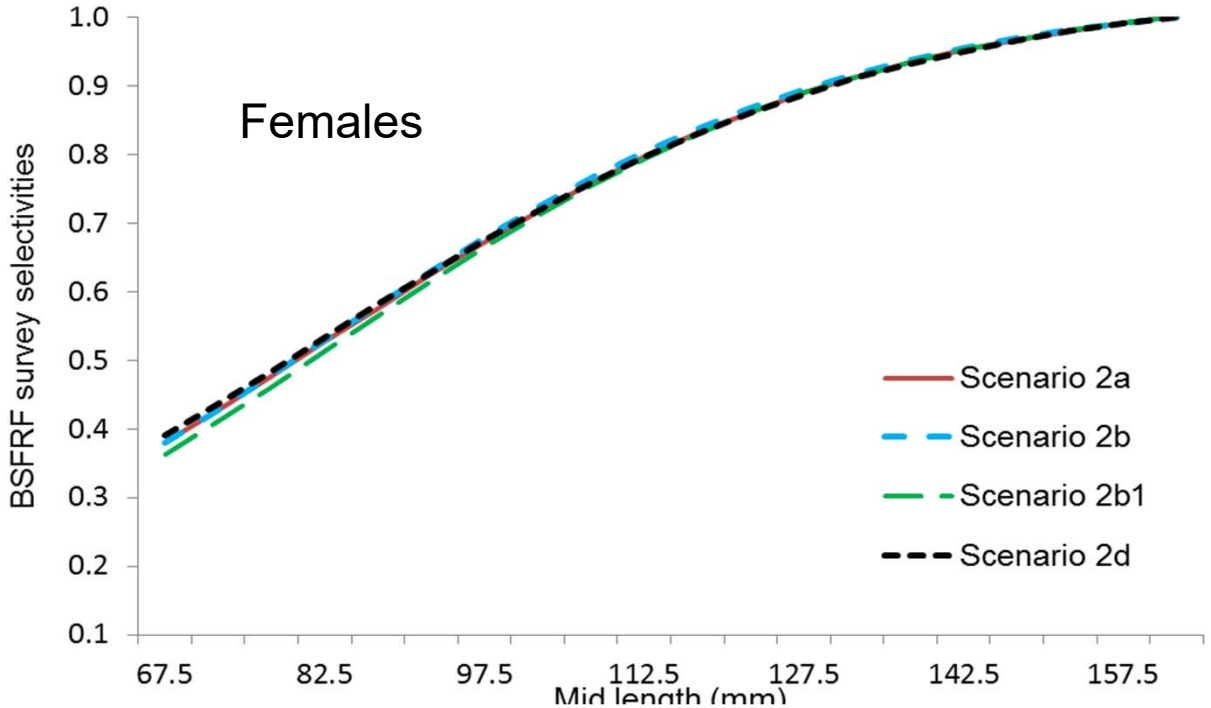


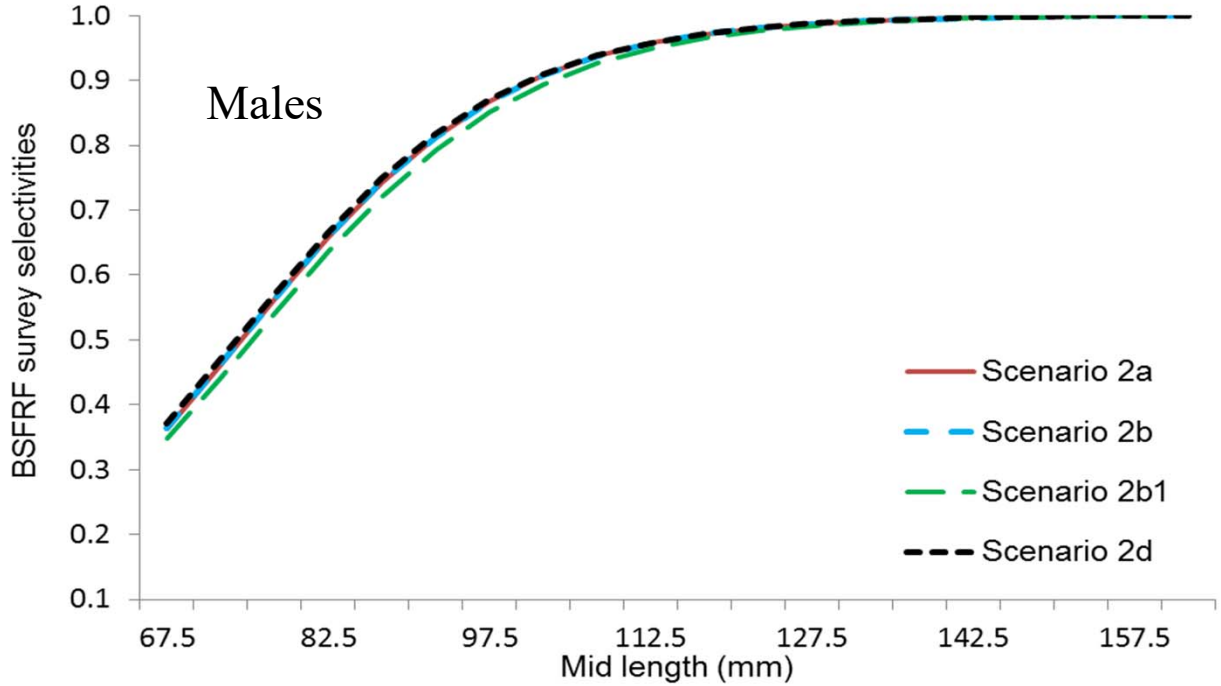
NMFS survey:
Scenario 2b


Females
NMFS survey selectivities
1.1
0.9
0.7
0.5
0.3
0.1
67.5
82.5
97.5
112.5
127.5
142.5
157.5
Scenario 2a
Scenario 2b
Scenario 2b1
Scenario 2d

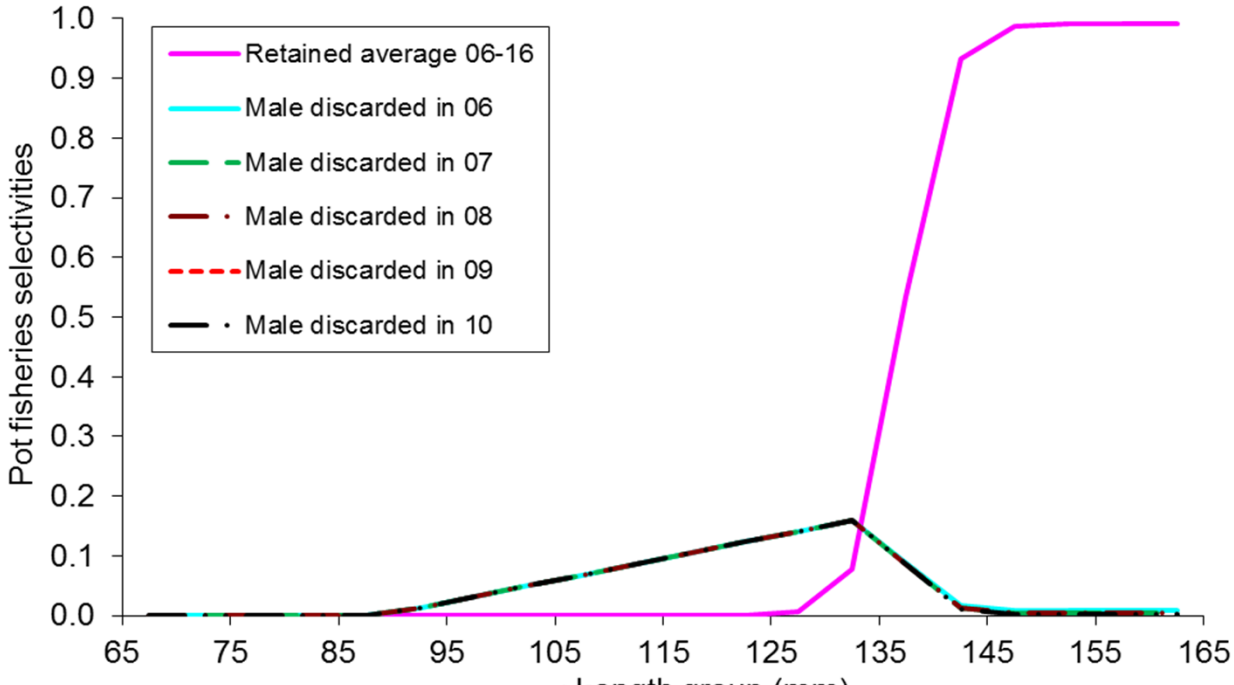
1982-2017

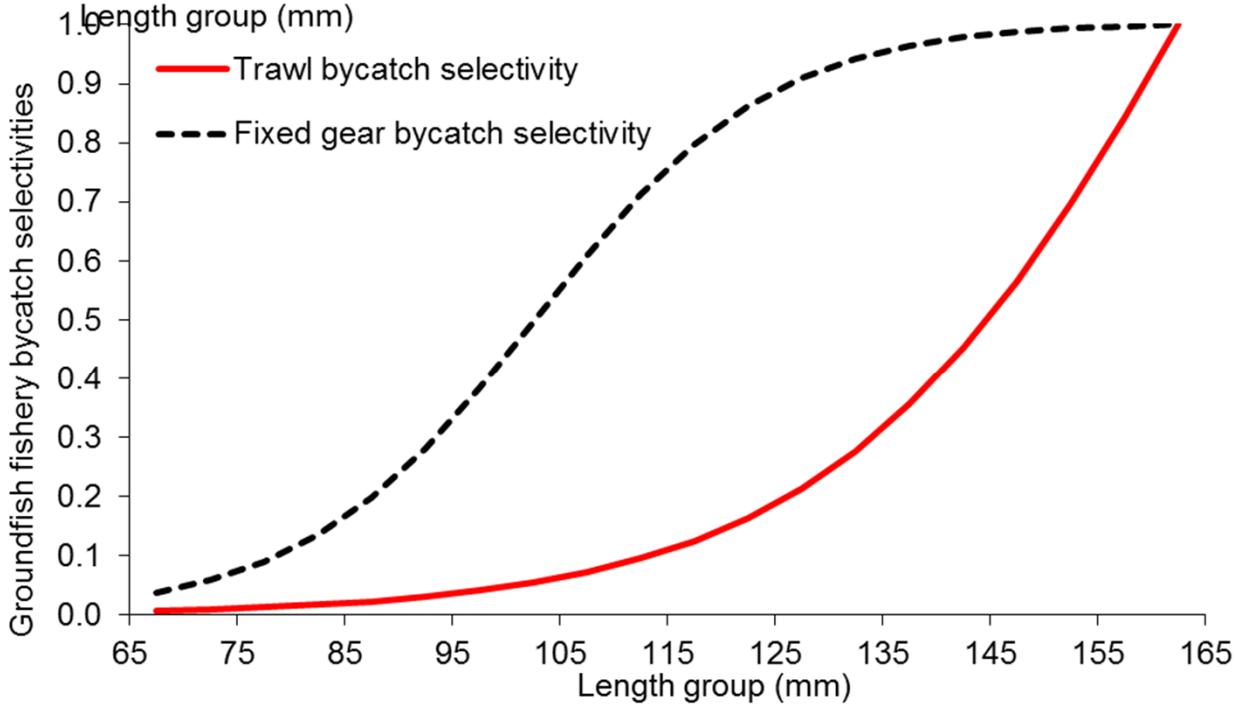

Males
NMFS survey selectivities
1.1
0.9
0.7
0.5
0.3
0.1
67.5
82.5
97.5
112.5
127.5
142.5
157.5
Mid length (mm)
Scenario 2a
Scenario 2b
Scenario 2b1
Scenario 2d

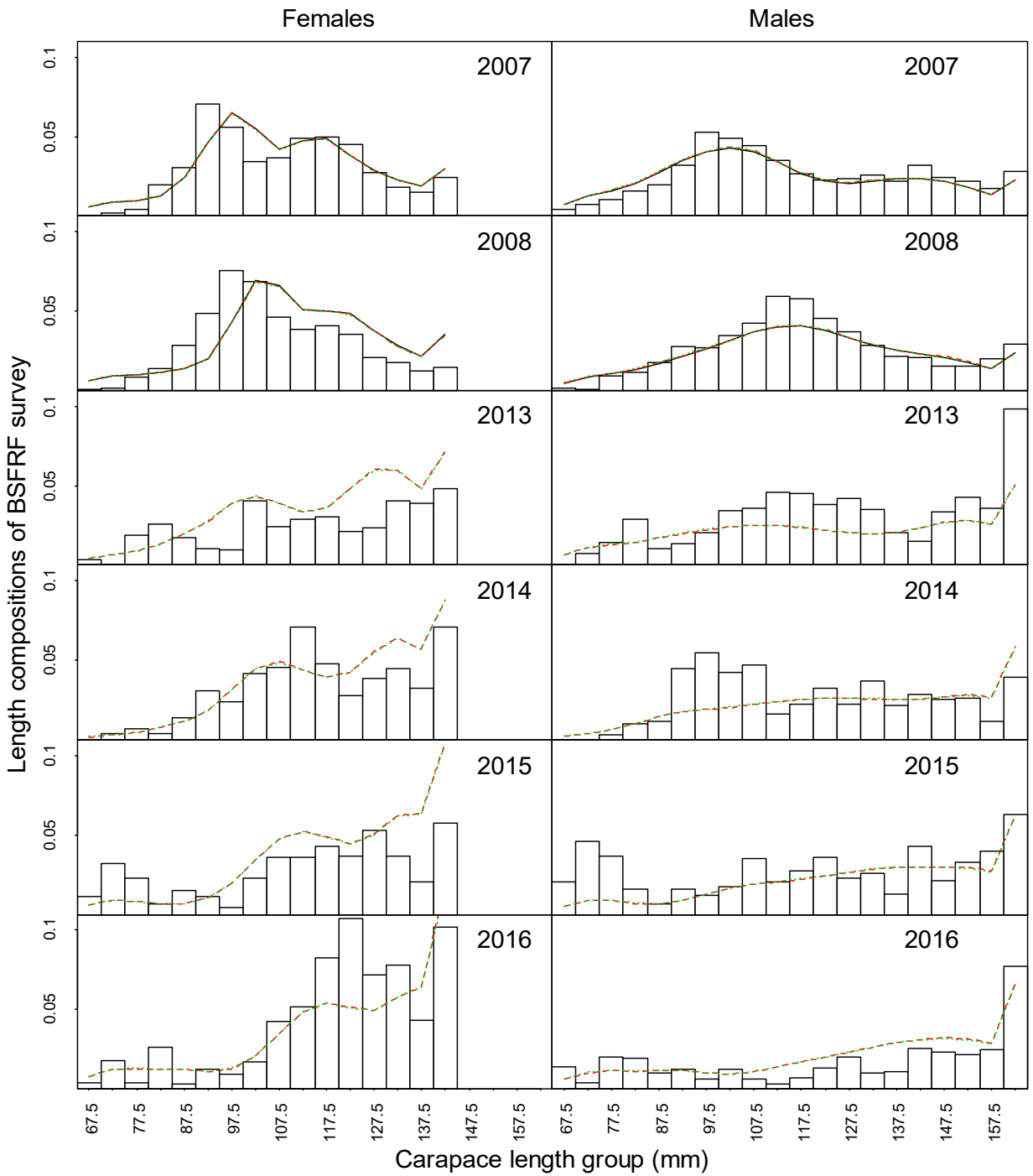

Females
BSFRF survey selectivities
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
67.5
82.5
97.5
112.5
127.5
142.5
157.5
Mid length (mm)
Scenario 2a
Scenario 2b
Scenario 2b1
Scenario 2d


Males
BSFRF survey selectivities
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
67.5
82.5
97.5
112.5
127.5
142.5
157.5
Mid length (mm)
Scenario 2a
Scenario 2b
Scenario 2b1
Scenario 2d

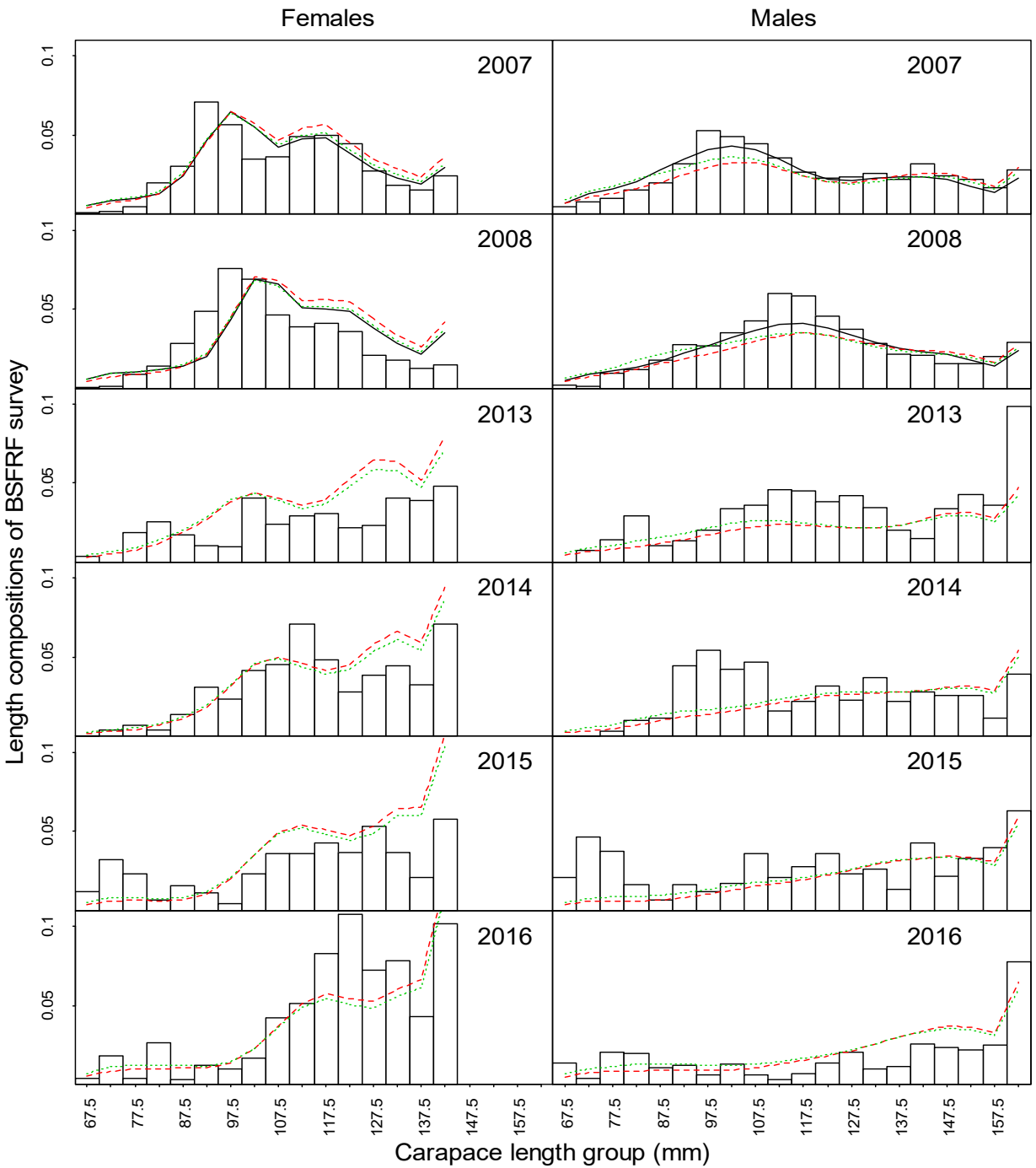
Scenario 2b


Retained average 06-16
Male discarded in 06
Male discarded in 07
Male discarded in 08
Male discarded in 09
Male discarded in 10
Pot fisheries selectivities
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
65
75
85
95
105
115
125
135
145
155
165
Length group (mm)

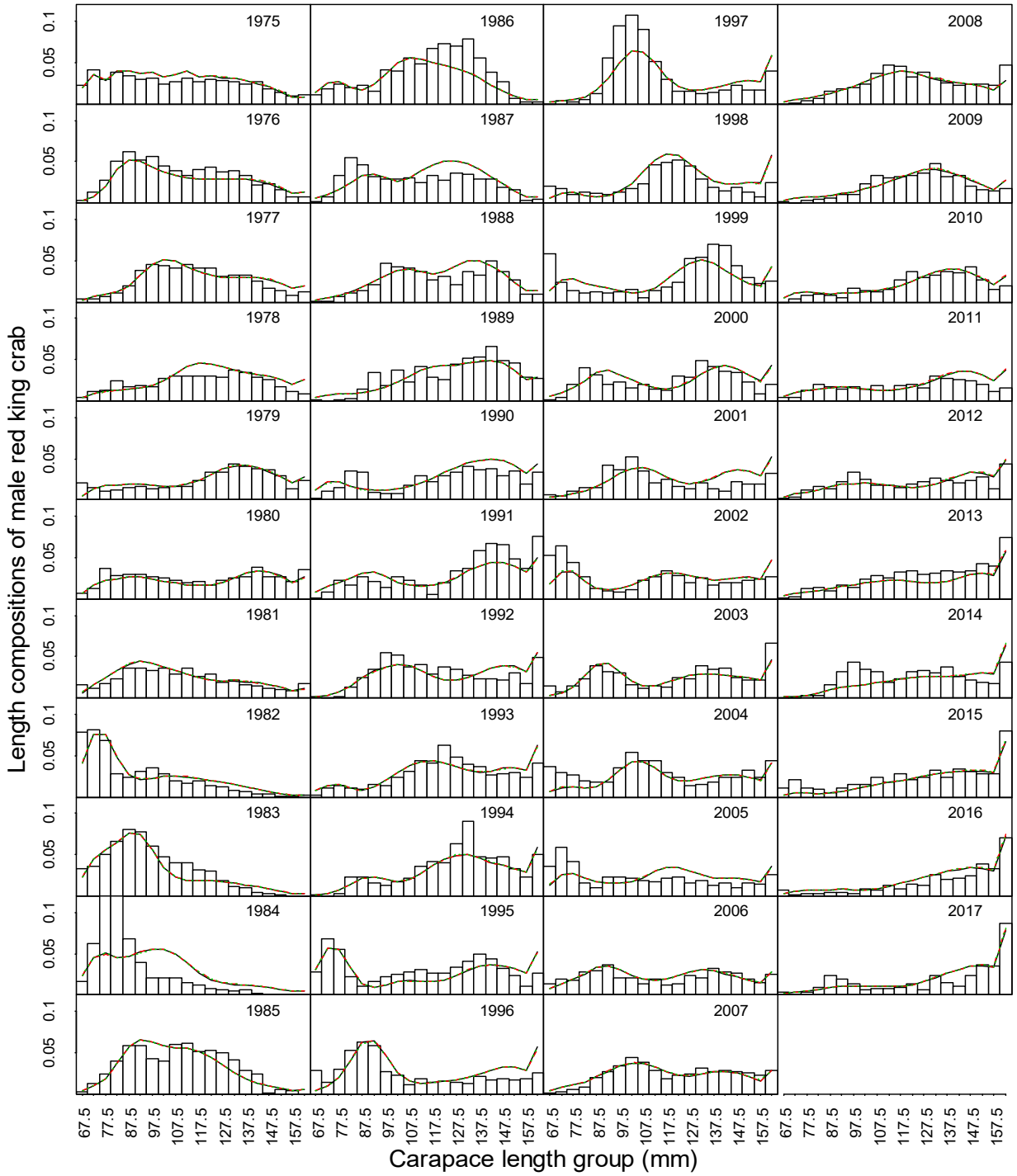

Trawl bycatch selectivity
Fixed gear bycatch selectivity
Groundfish fishery bycatch selectivities
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
65
75
85
95
105
115
125
135
145
155
165
Length group (mm)



BSFRF survey length frequency. Scenarios 2a (solid black), 2b (dashed red), and 2d (green lines)



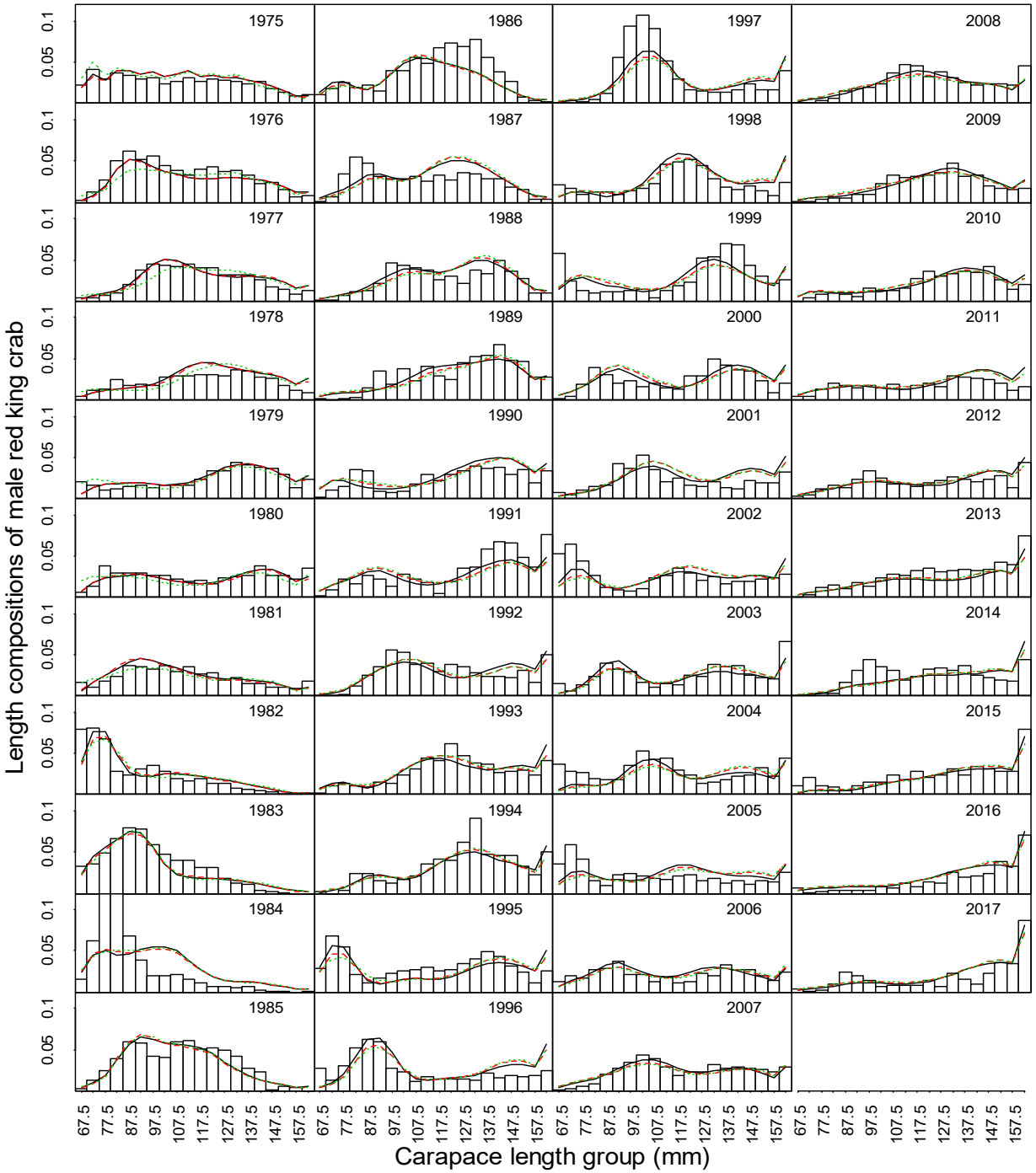
BSFRF survey length frequency. Scenarios 2b (solid black), 2b1 (dashed red), and 2b2 (green lines)



NMFS Survey

Scenarios 2a(black), 2b(red), and 2d(green).

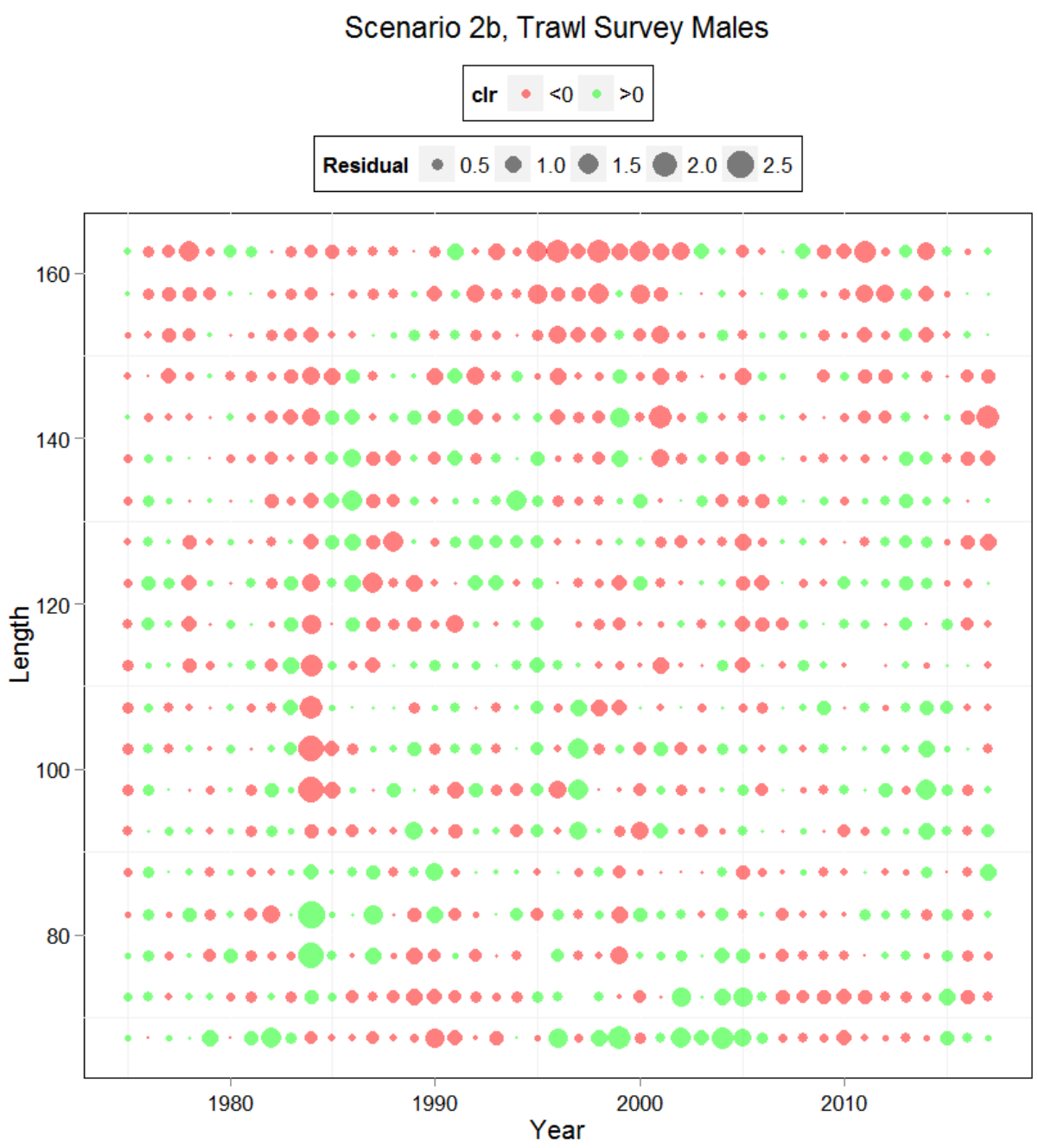
Males

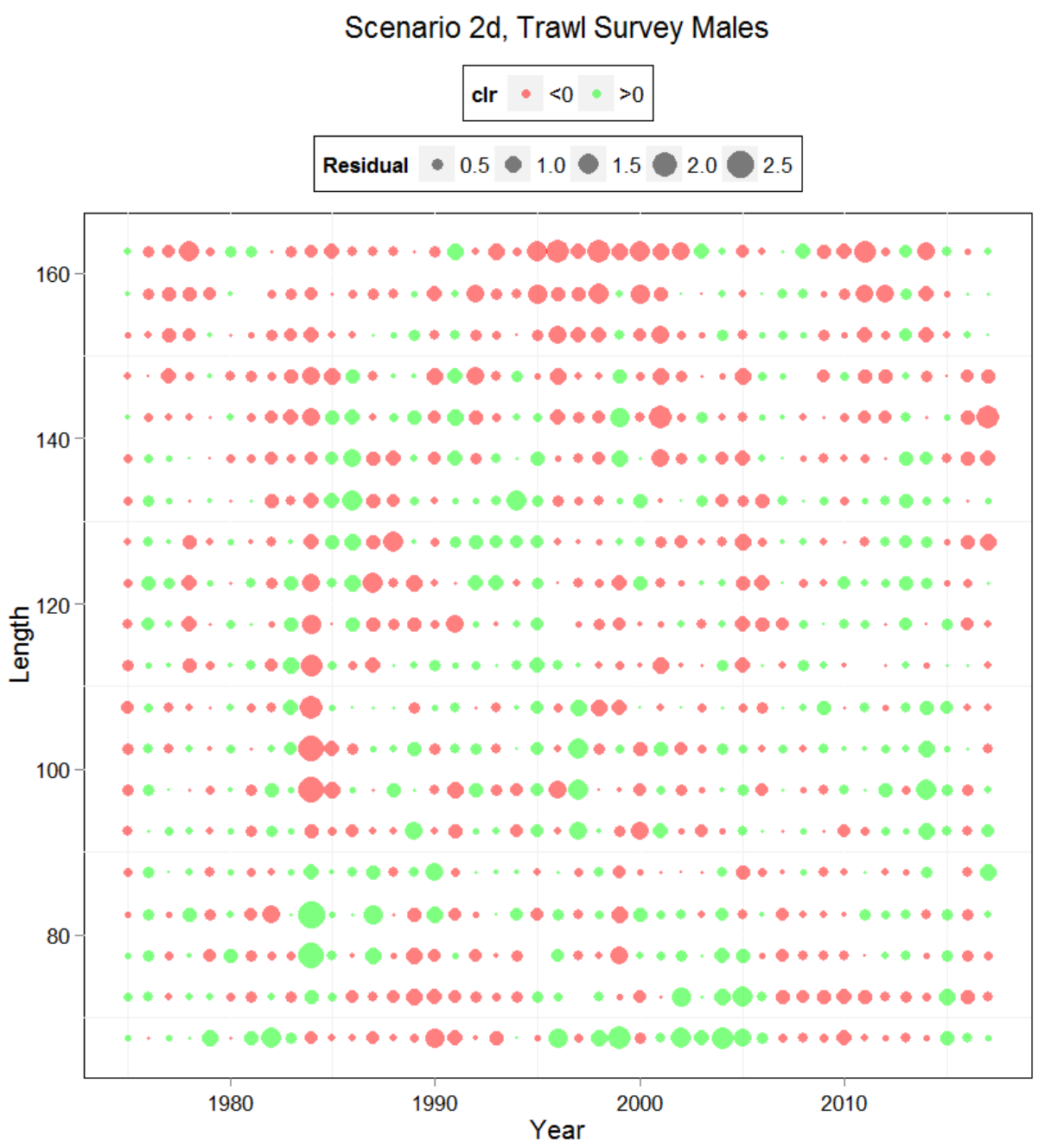


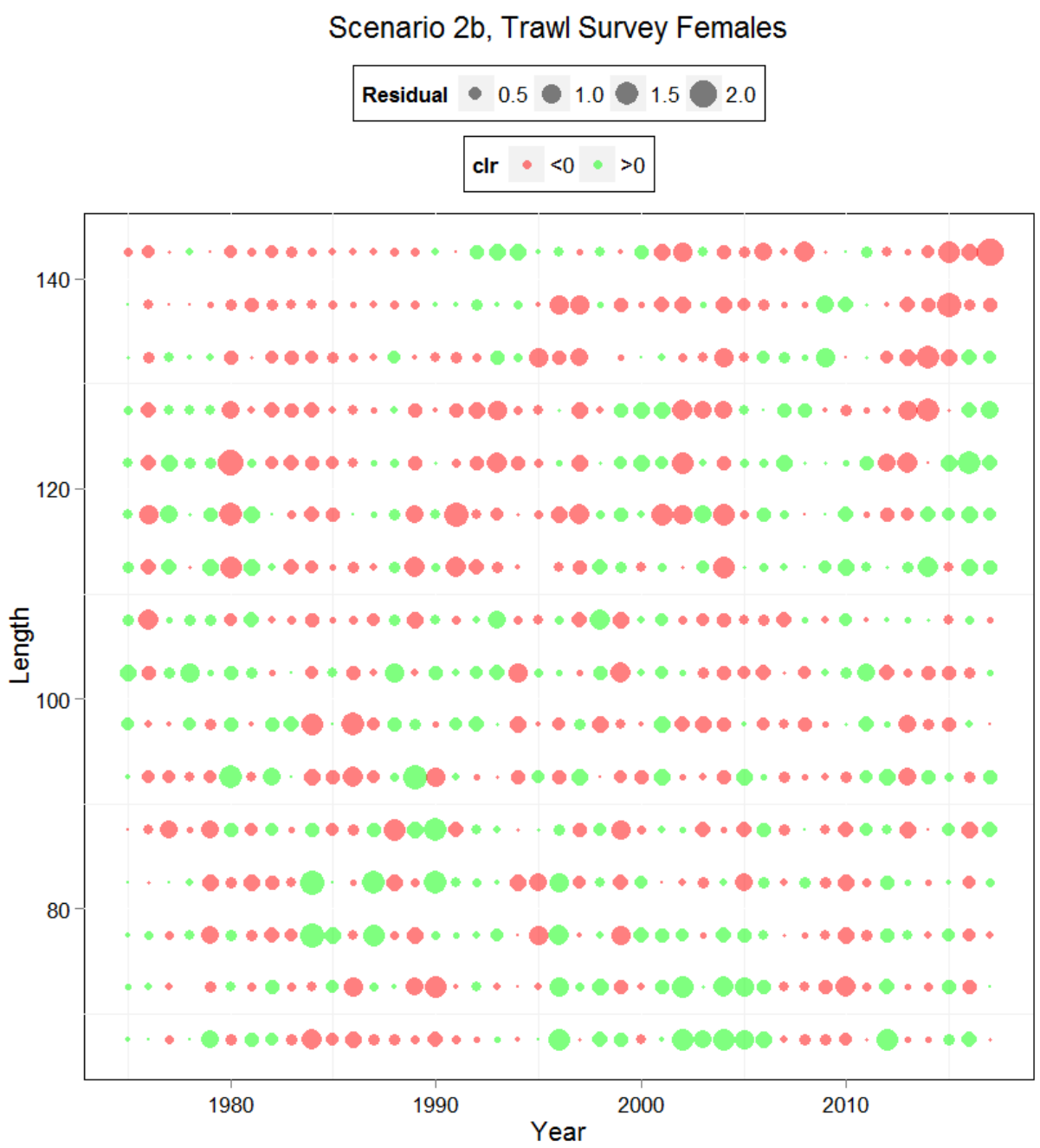
NMFS Survey

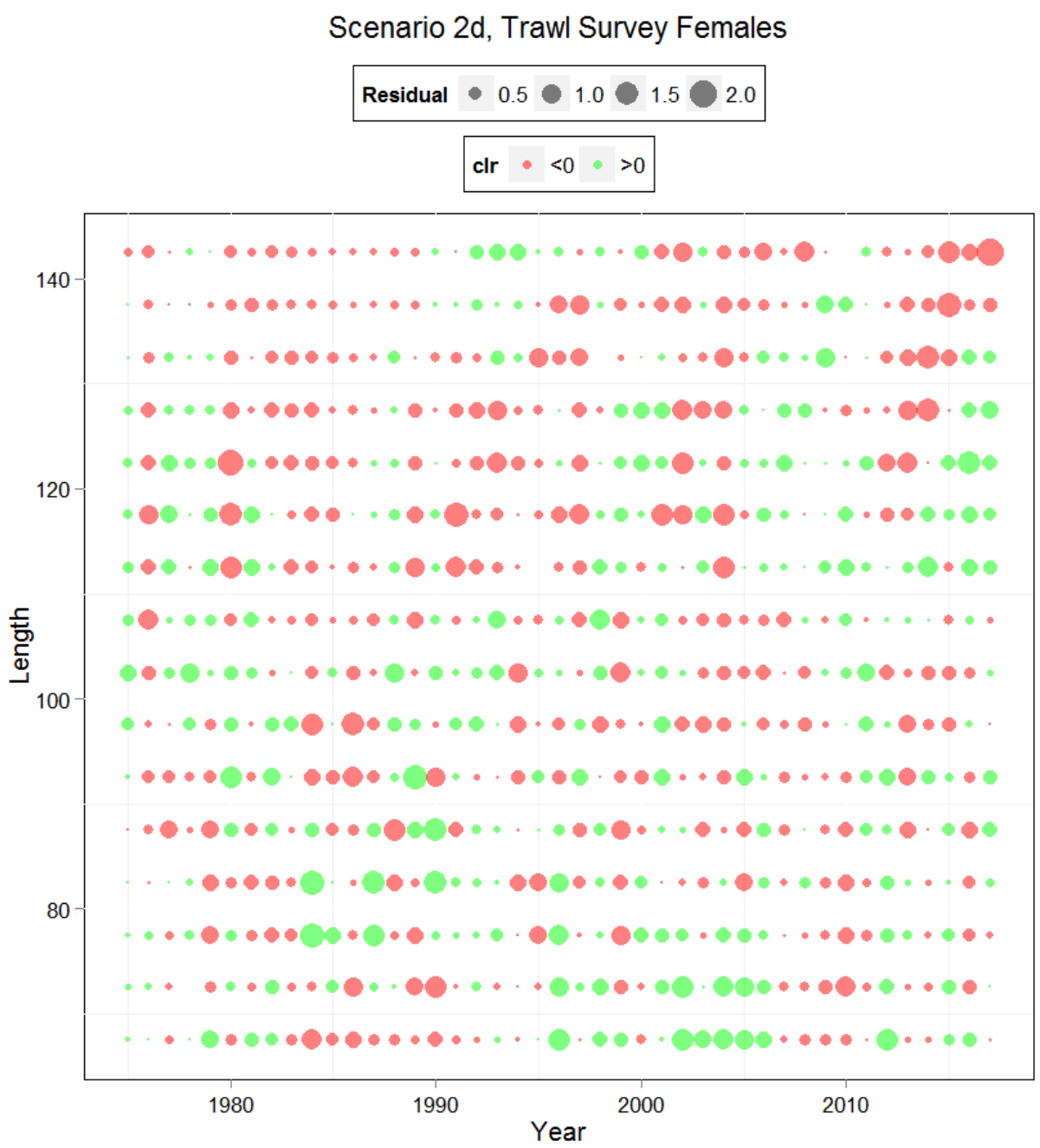
Scenarios 2b(black), 2b1(red), and 2b2(green).

Males

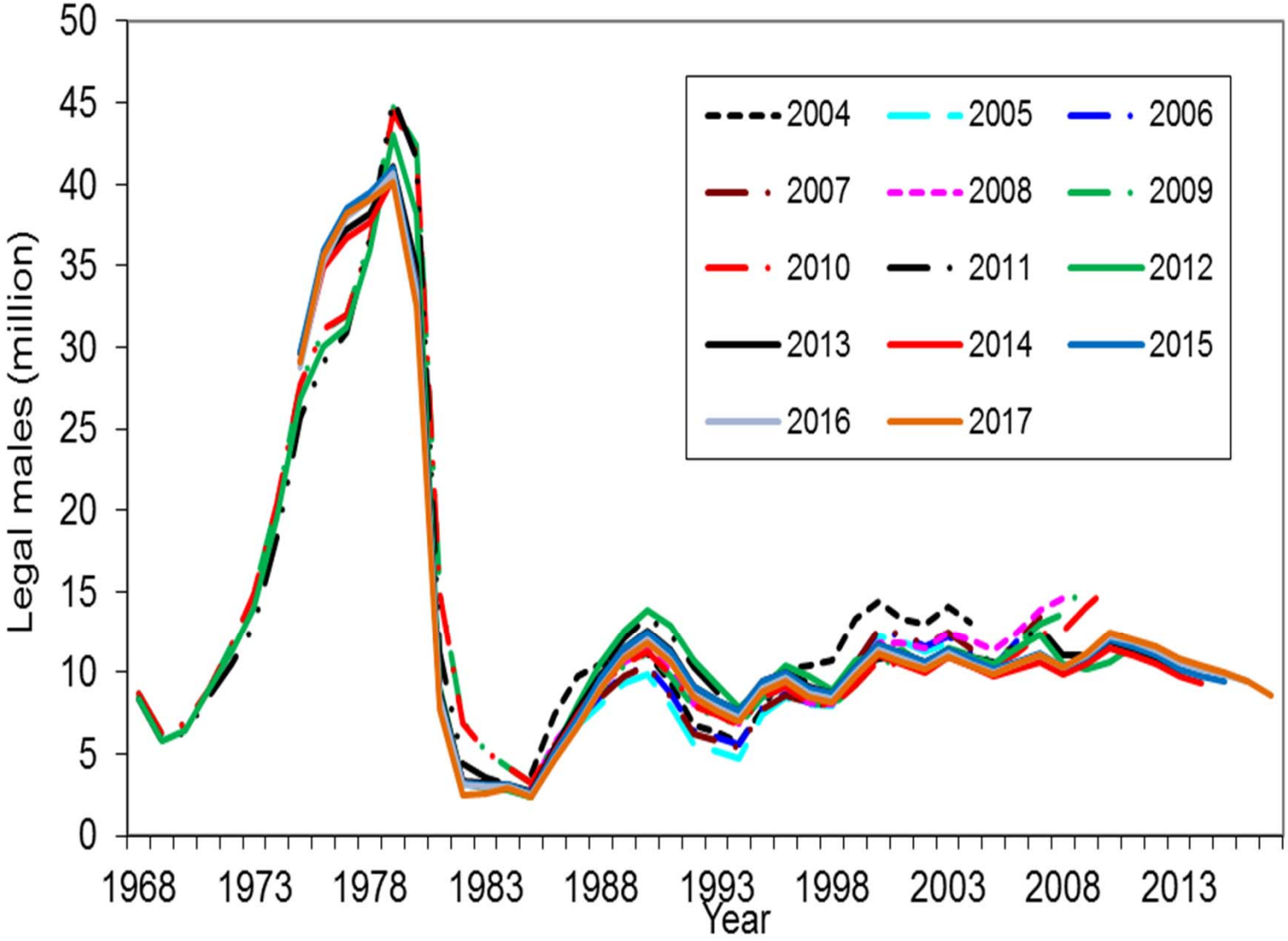

Scenario 2b, Trawl Survey Males
clr
<0
>0
Residual
0.5
1.0
1.5
2.0
2.5
160
140
120
100
80
Length
1980
1990
2000
2010
Year


Scenario 2d, Trawl Survey Males
clr
<0
>0
Residual
0.5
1.0
1.5
2.0
2.5
160
140
120
100
80
Length
1980
1990
2000
2010
Year

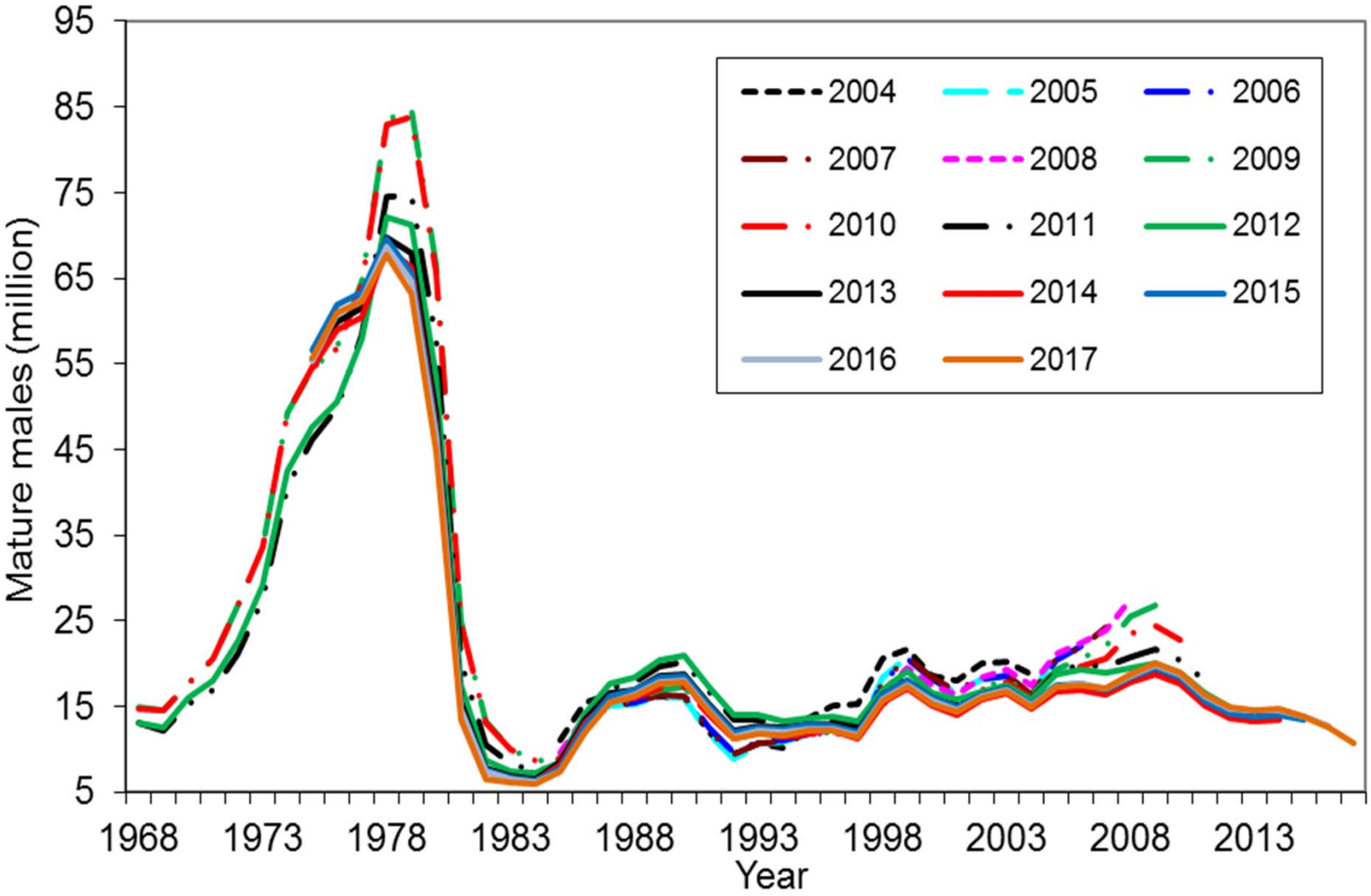

Scenario 2b, Trawl Survey Females
Residual 0.5 1.0 1.5 2.0
clr <0 >0
140
120
100
80
Length
1980
1990
2000
2010
Year


Scenario 2d, Trawl Survey Females
Residual
0.5
1.0
1.5
2.0
clr
<0
>0
140
120
100
80
Length
1980
1990
2000
2010
Year

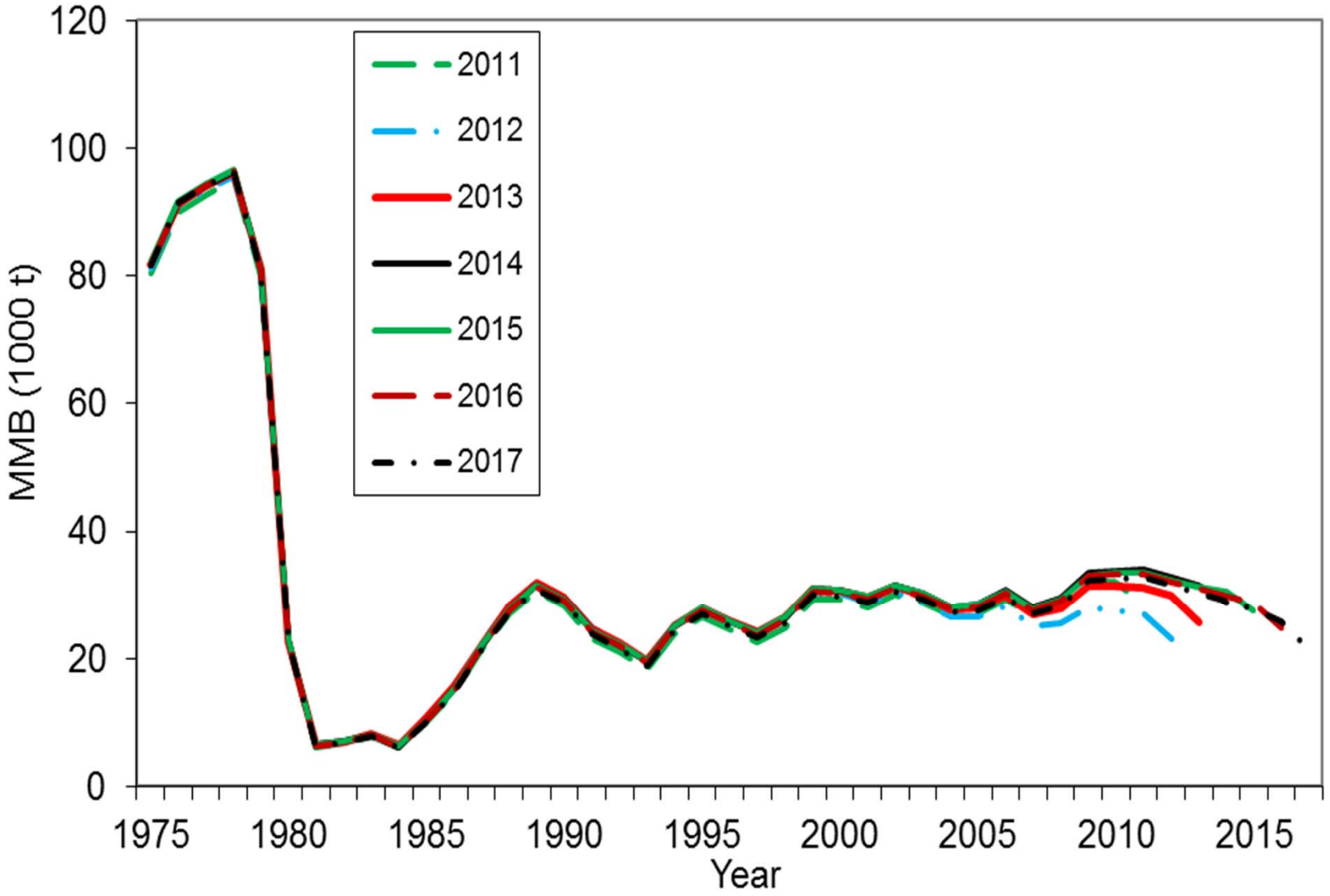
Scenario 2b, historical results



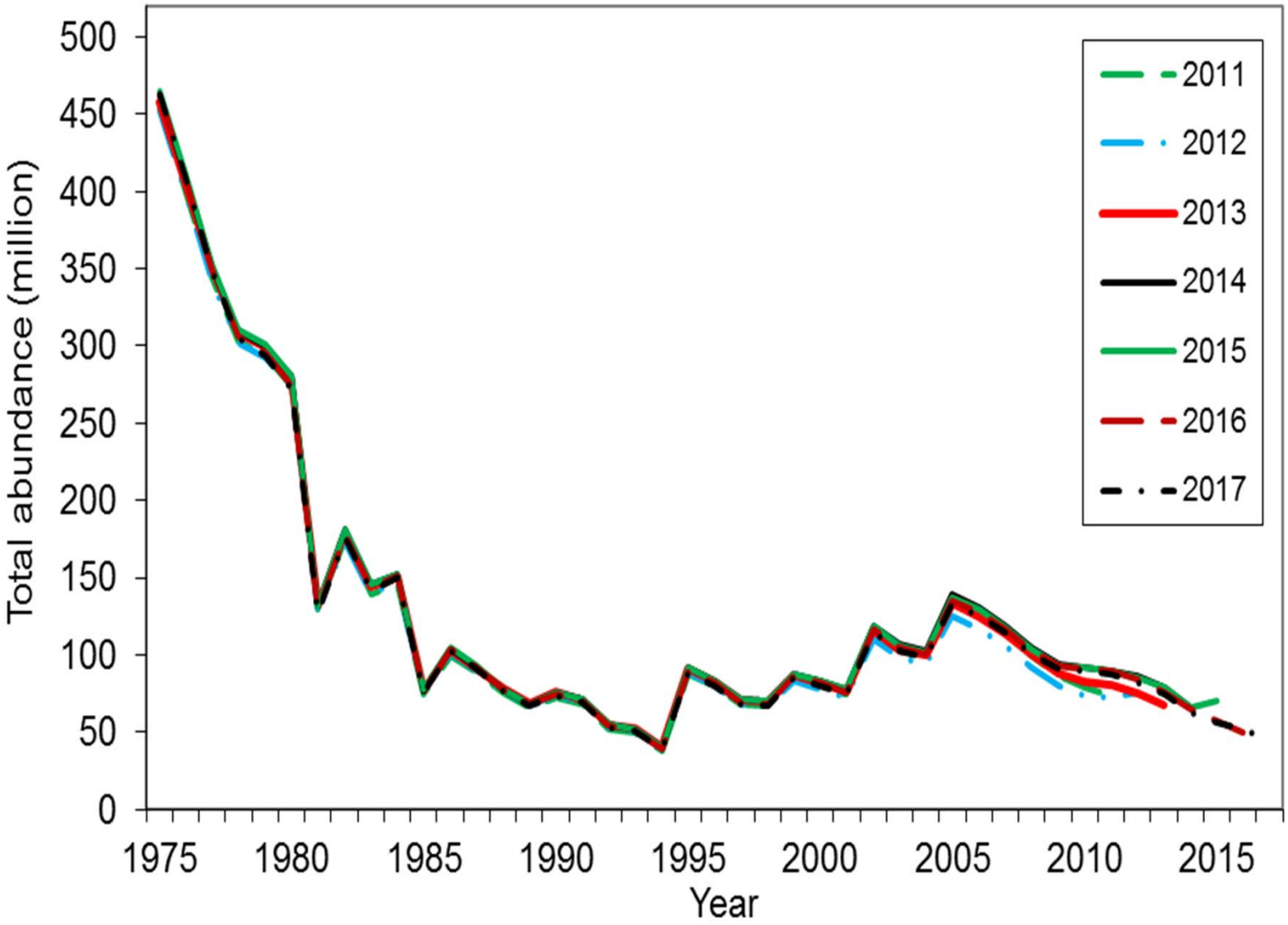
Scenario 2b, historical results



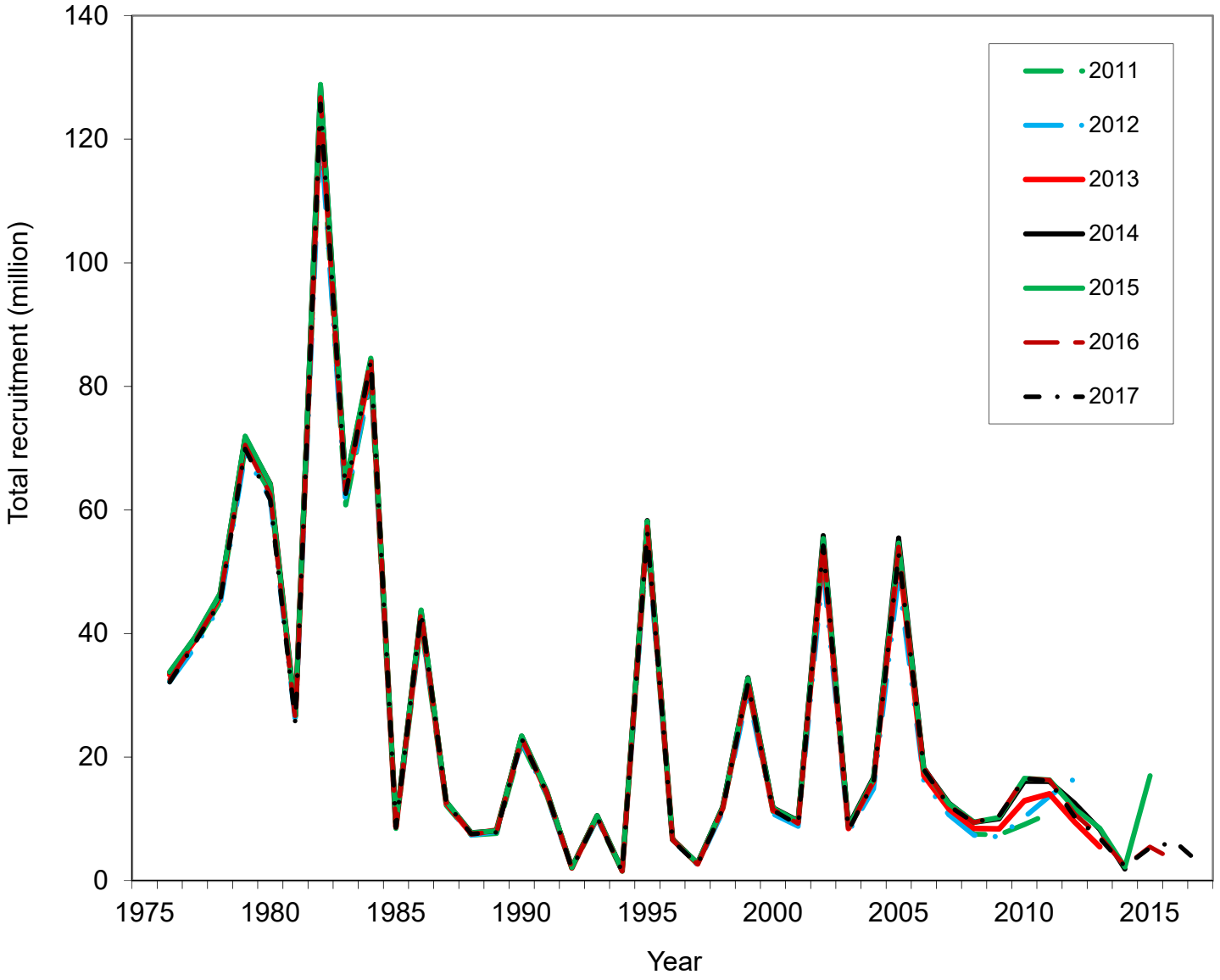
Scenario 2b, 2017 model results



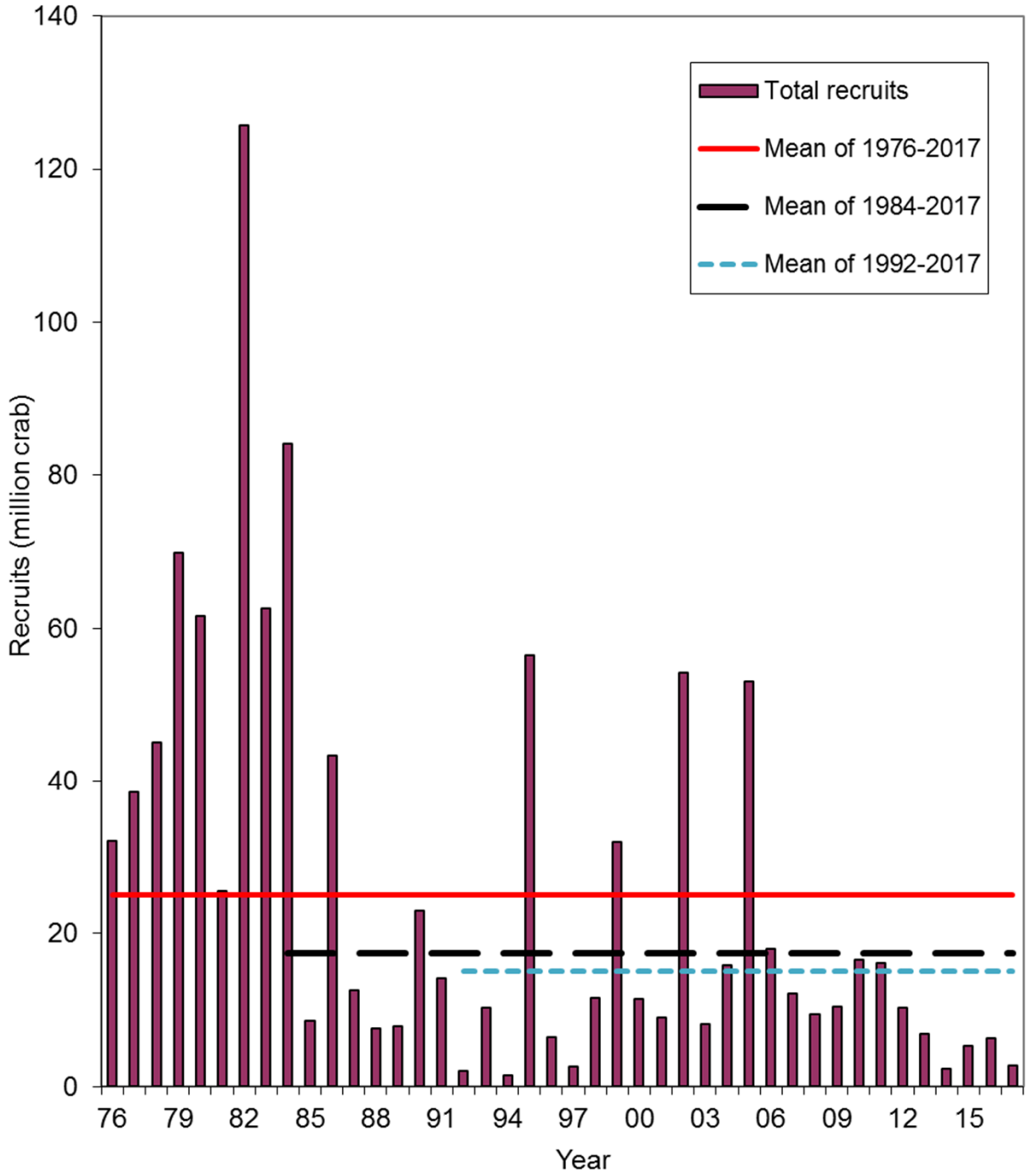
Scenario 2b, 2017 model results

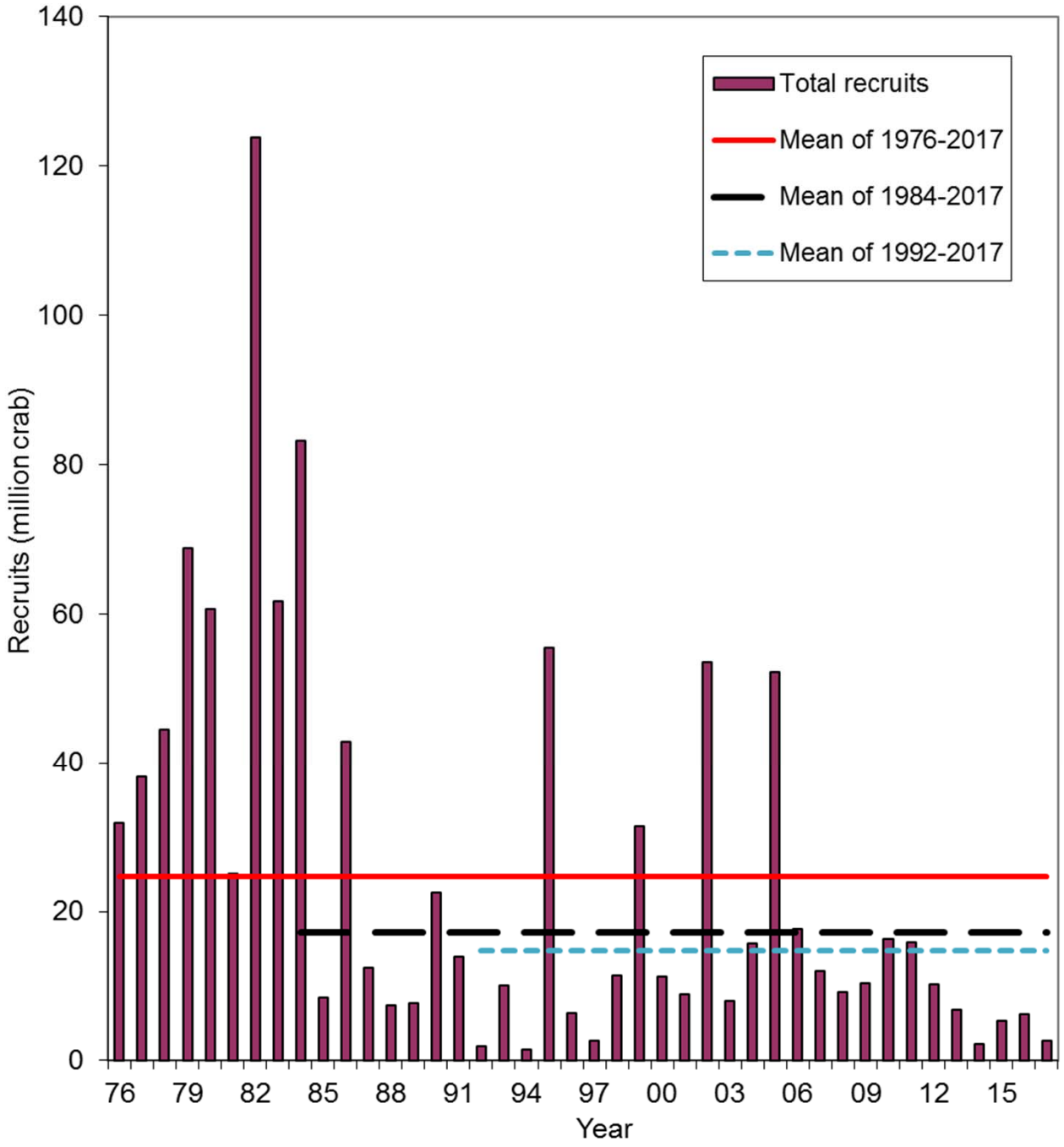


Scenario 2b, 2017 model results



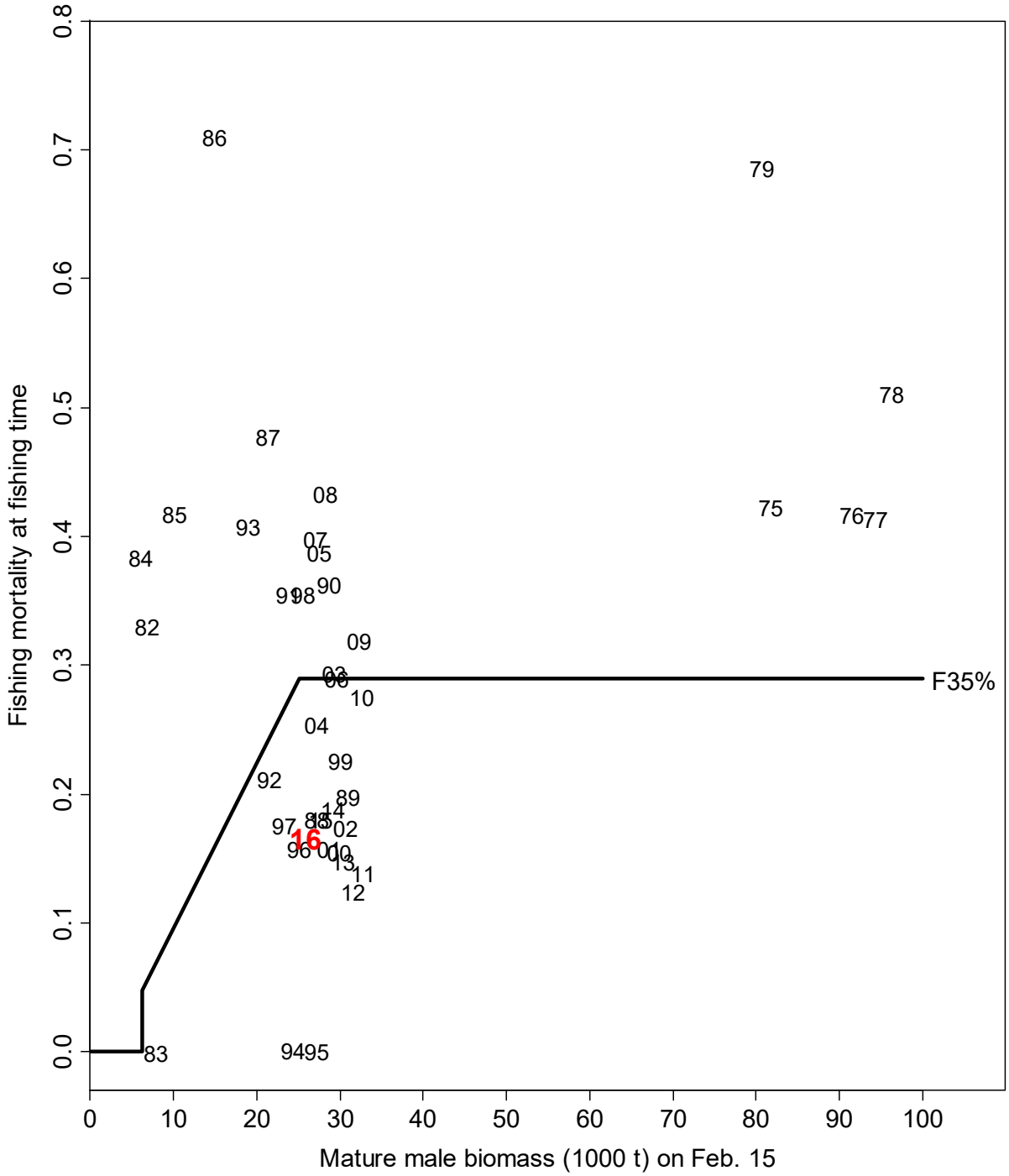
Scenario 2b


Total recruits
Mean of 1976-2017
Mean of 1984-2017
Mean of 1992-2017
Recruits (million crab)
140
120
100
80
60
40
20
0
76
79
82
85
88
91
94
97
00
03
06
09
12
15
Year

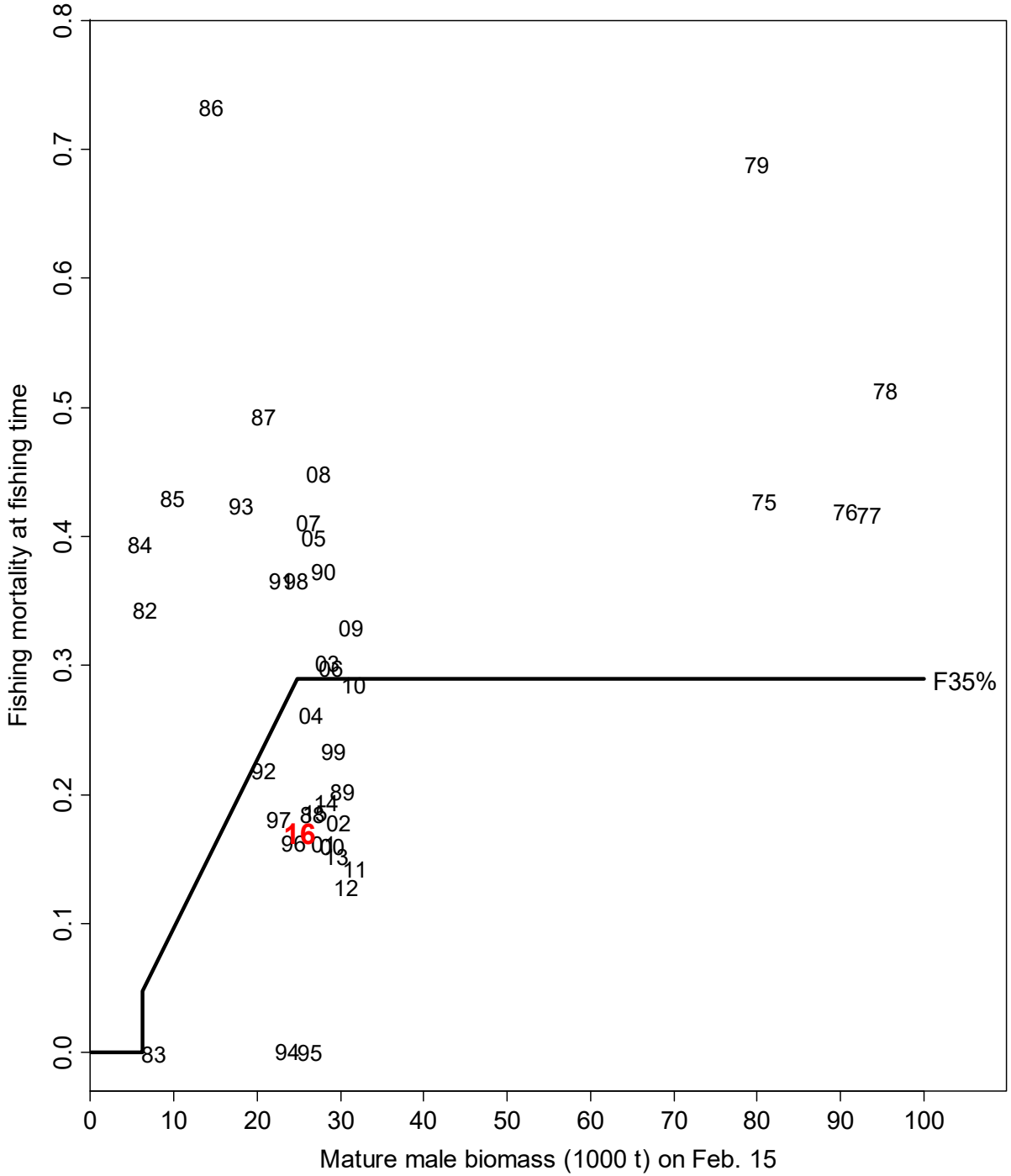

Total recruits
Mean of 1976-2017
Mean of 1984-2017
Mean of 1992-2017
Recruits (million crab)
Year
0
20
40
60
80
100
120
140
76
79
82
85
88
91
94
97
00
03
06
09
12
15

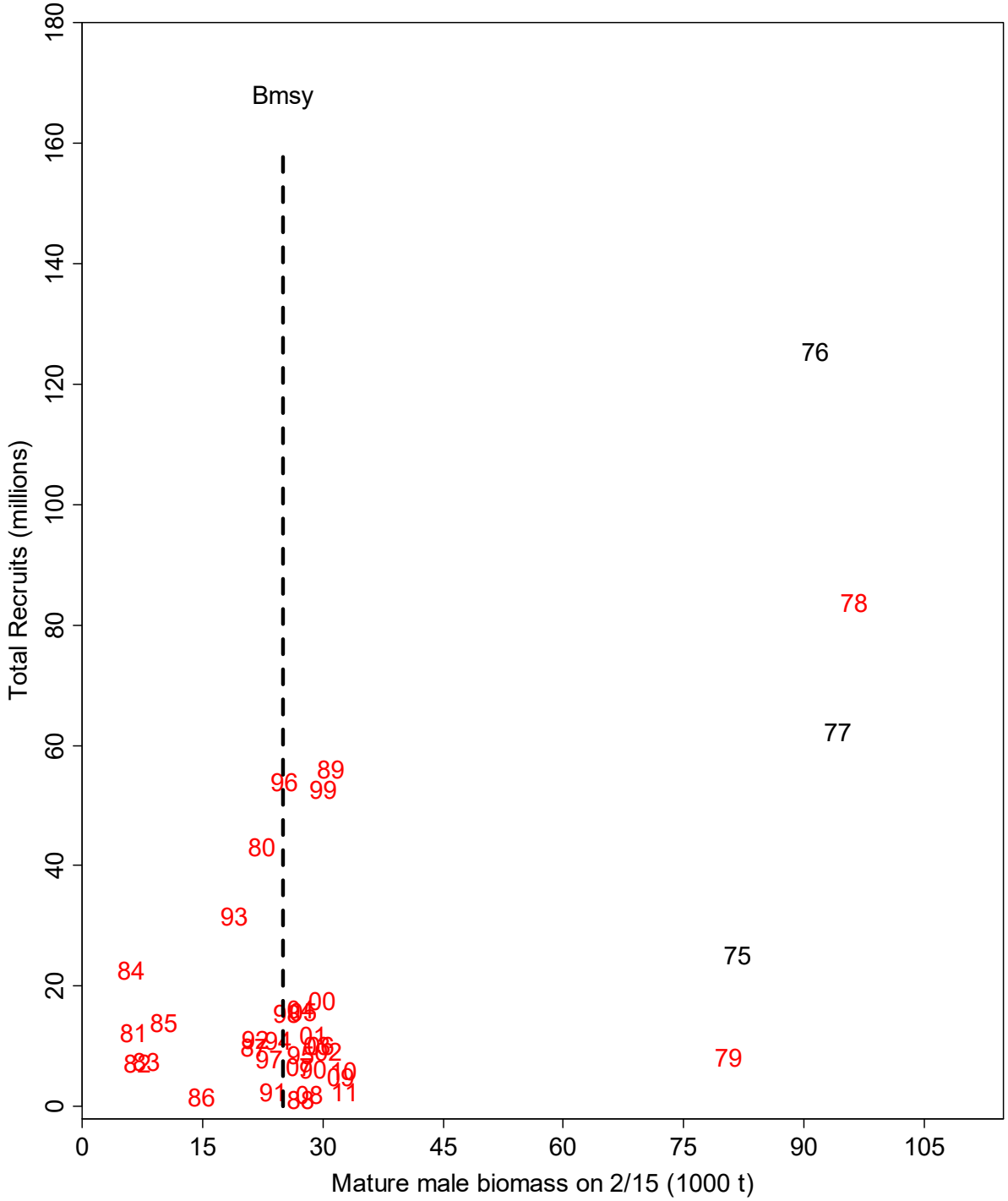
Scenario 2d

Scenario 2b

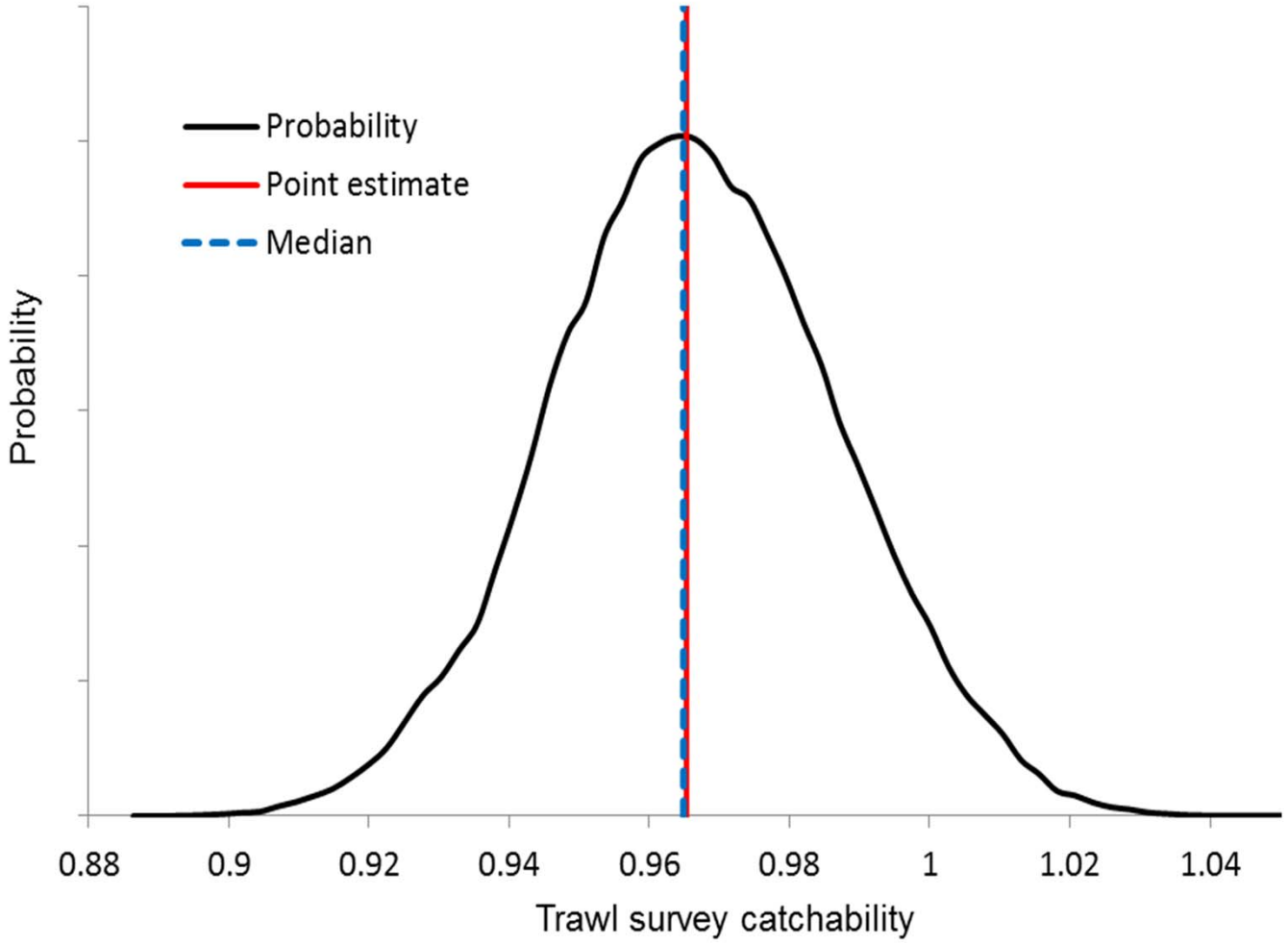

Fishing mortality at fishing time
Mature male biomass (1000 t) on Feb. 15
F35%
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60
70
80
90
100
86
79
78
87
08
85
75
76
77
93
07
05
84
90
98
82
09
10
04
99
92
89
14
02
16
11
12
83
94
95

Scenario 2d

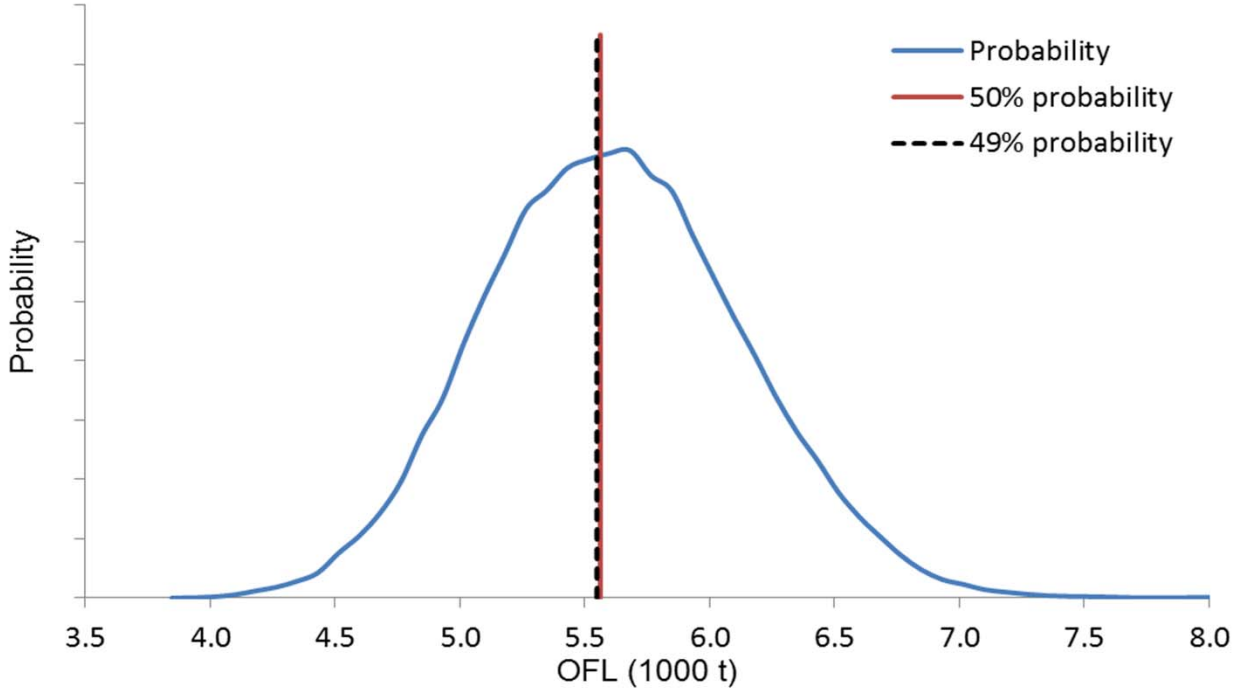

Fishing mortality at fishing time
Mature male biomass (1000 t) on Feb. 15
F35%
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60
70
80
90
100
86
79
78
87
08
85
93
75
76
77
07
05
84
90
82
09
10
04
99
92
89
14
02
16
13
11
12
83
94
95


Bmsy
Total Recruits (millions)
Mature male biomass on 2/15 (1000 t)
0
20
40
60
80
100
120
140
160
180
0
15
30
45
60
75
90
105
76
78
77
89
96
99
80
93
75
84
85
81
79
86
91
11

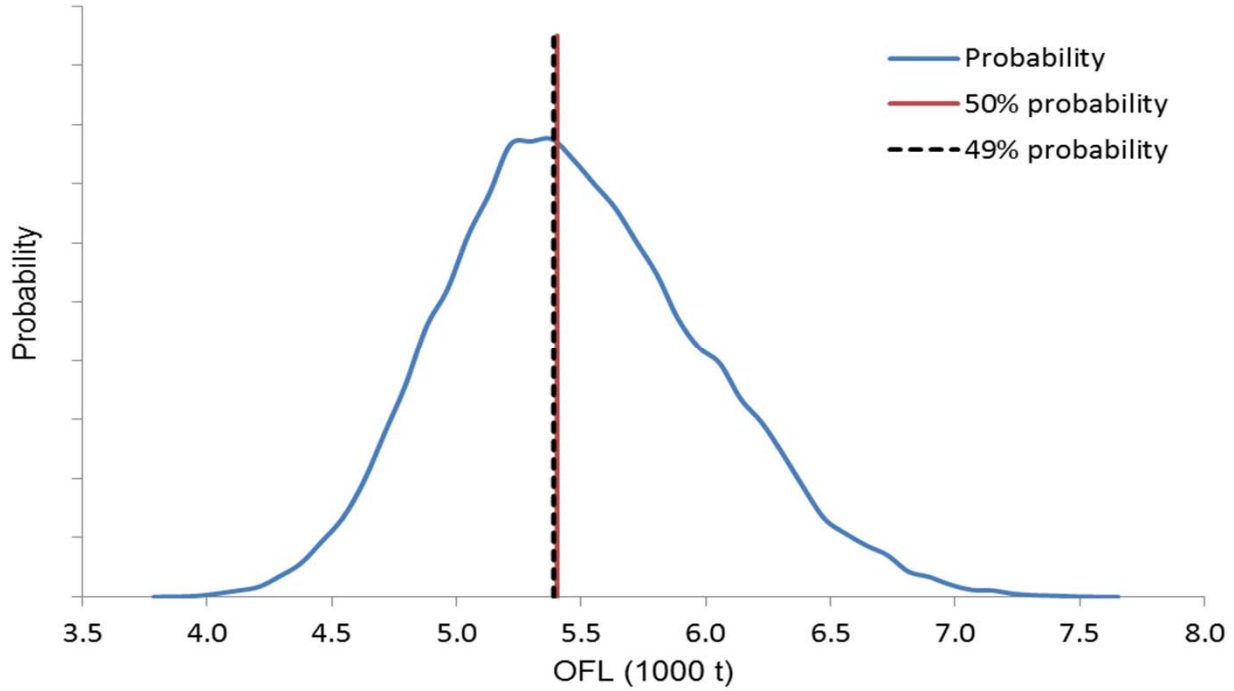
Scenario 2b



Scenario 2b
2017



Scenario 2b
2017



Scenario 2d
2017

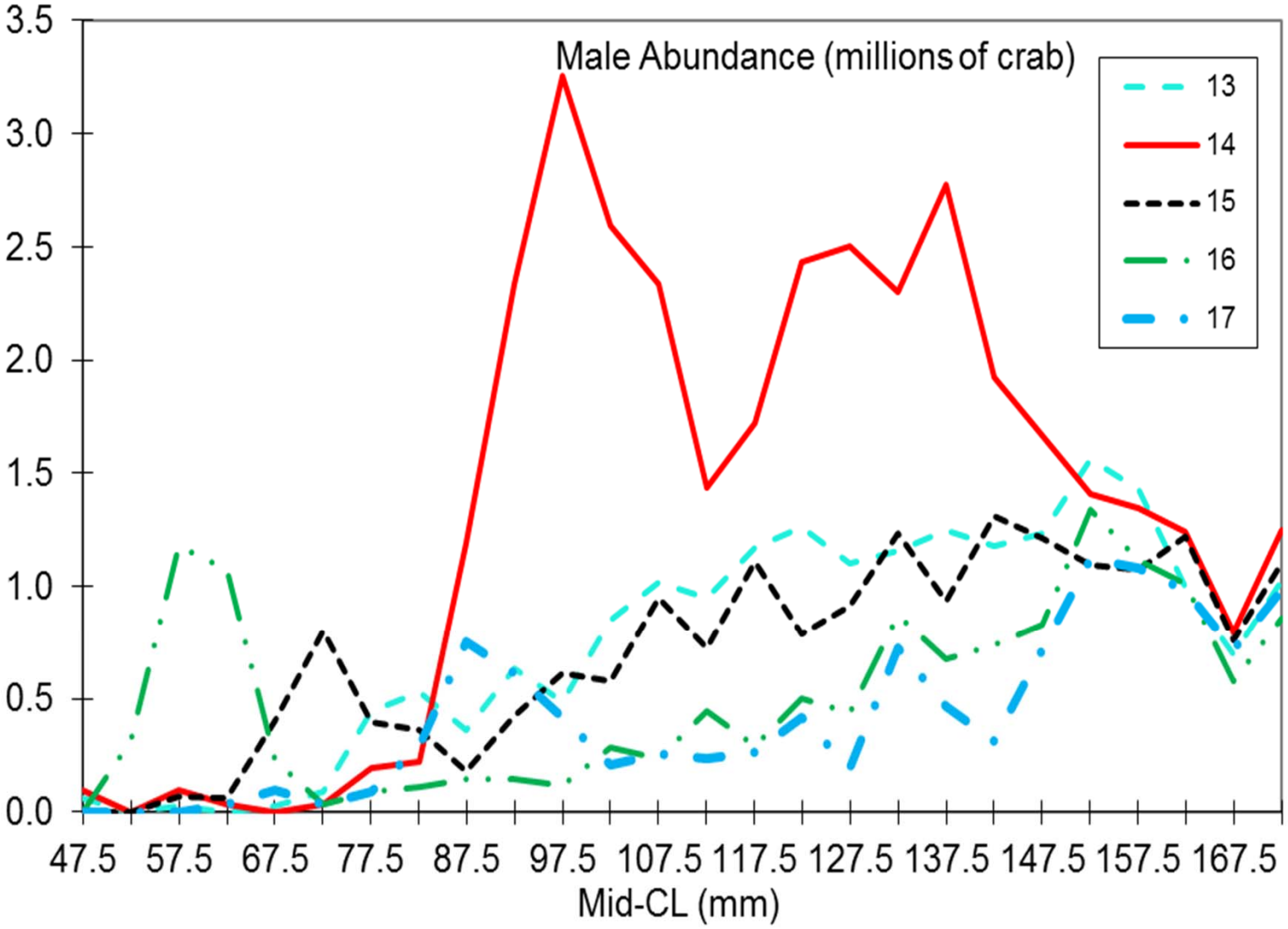
Status and catch specifications in 1000 t (scenario 2b):

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	12.85[A]	27.12[A]	3.90	3.99	4.56	7.07	6.36
2014/15	13.03[B]	27.25[B]	4.49	4.54	5.44	6.82	6.14
2015/16	12.89[C]	27.68[C]	4.52	4.61	5.34	6.73	6.06
2016/17	12.53[D]	25.81[D]	3.84	3.92	4.28	6.64	5.97
2017/18		21.31[D]				5.60	5.04

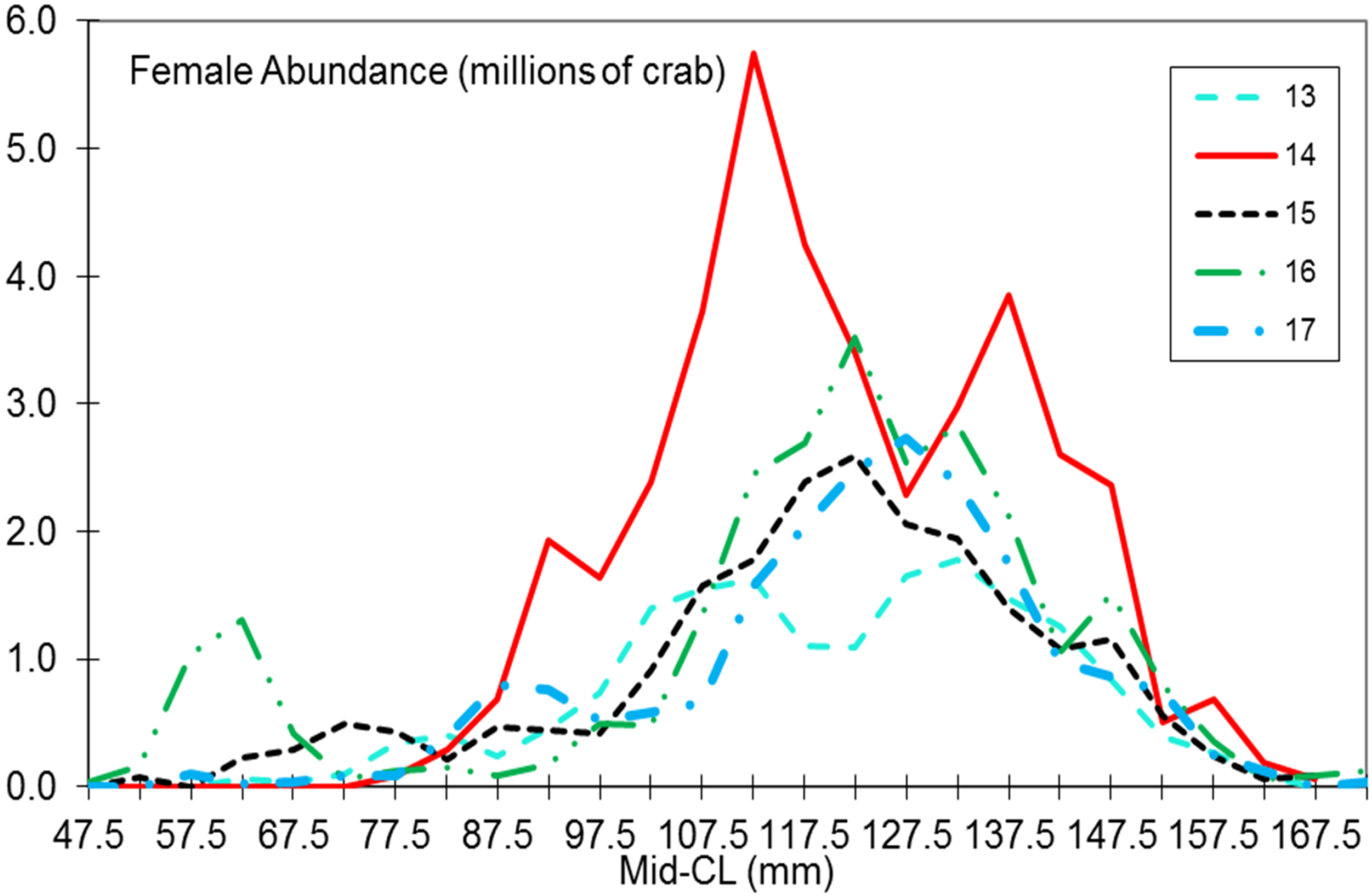
6. Basis for the OFL: All table values are in 1000 t (Scenario 2b):

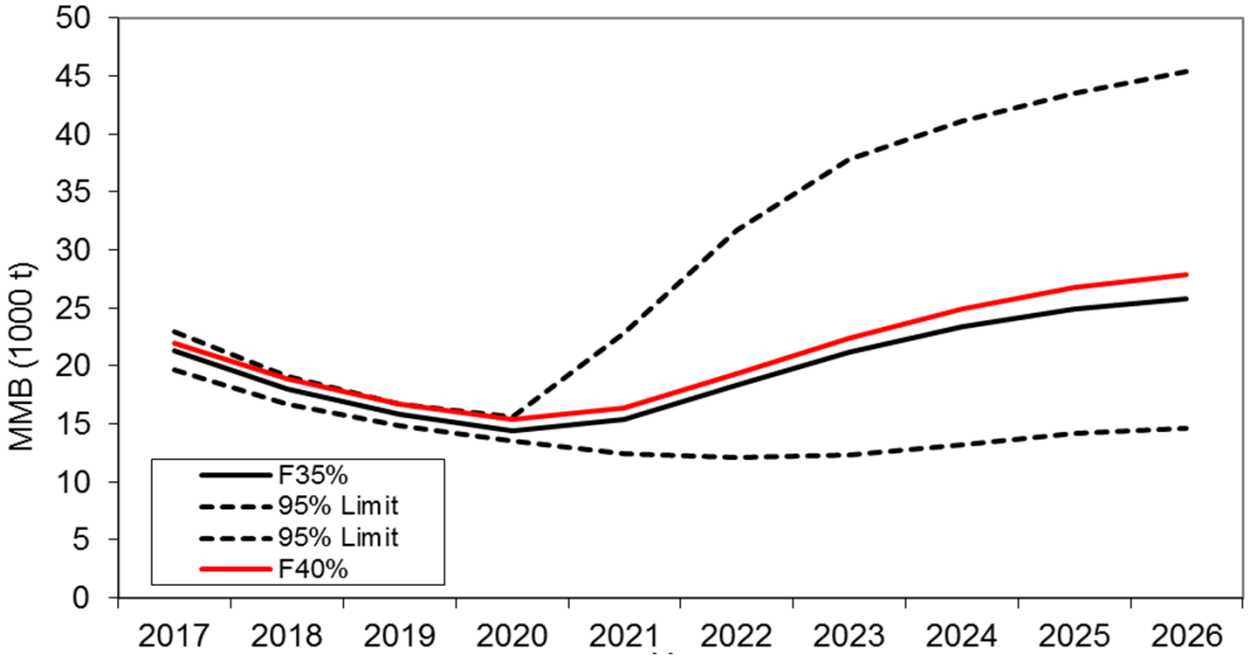
Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
2013/14	3b	26.4	25.0	0.95	0.27	1984-2013	0.18
2014/15	3b	25.7	24.7	0.96	0.28	1984-2014	0.18
2015/16	3b	26.1	24.7	0.95	0.27	1984-2015	0.18
2016/17	3b	25.8	24.0	0.93	0.27	1984-2016	0.18
2017/18	3b	25.1	21.3	0.85	0.24	1984-2017	0.18

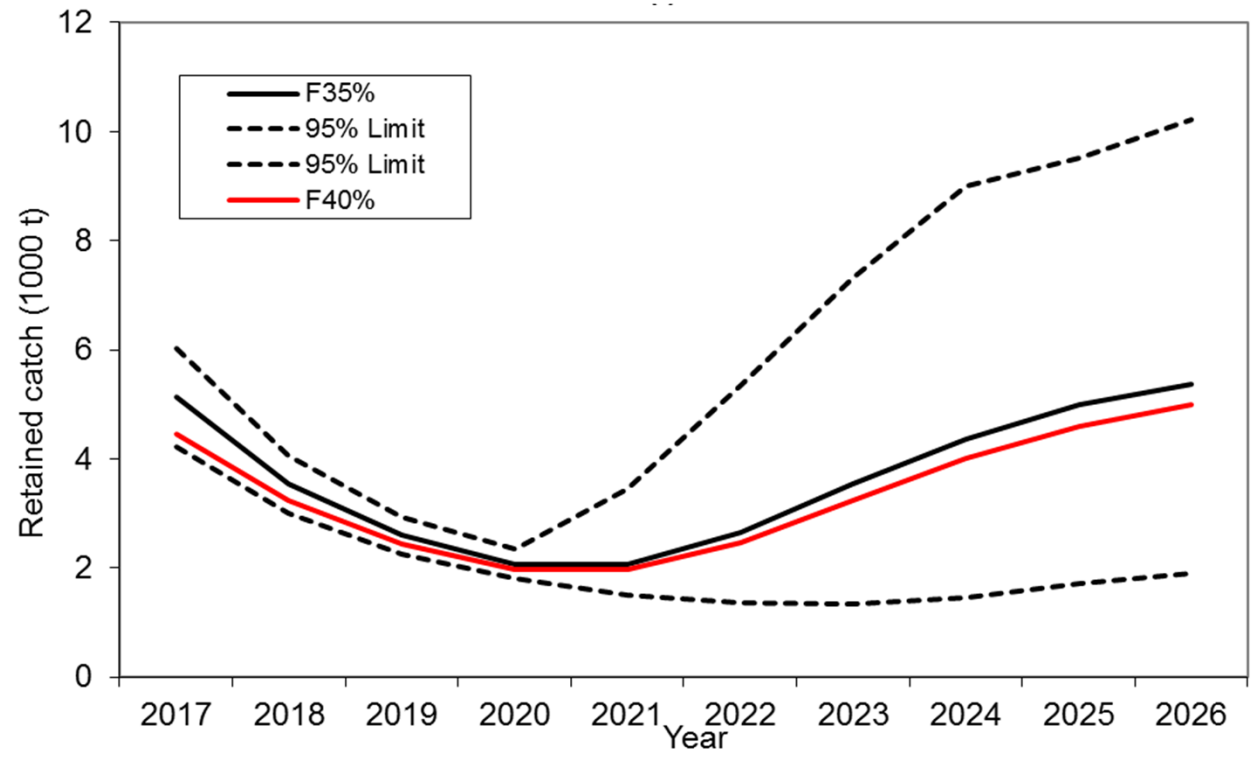
Male area-swept abundance during 2013-2017



Female area-swept abundance during 2013-2017




MMB (1000 t)
50
45
40
35
30
25
20
15
10
5
0
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
F35%
95% Limit
95% Limit
F40%


Retained catch (1000 t)
12
10
8
6
4
2
0
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
Year
F35%
95% Limit
95% Limit
F40%

Scenario 2b

Thanks