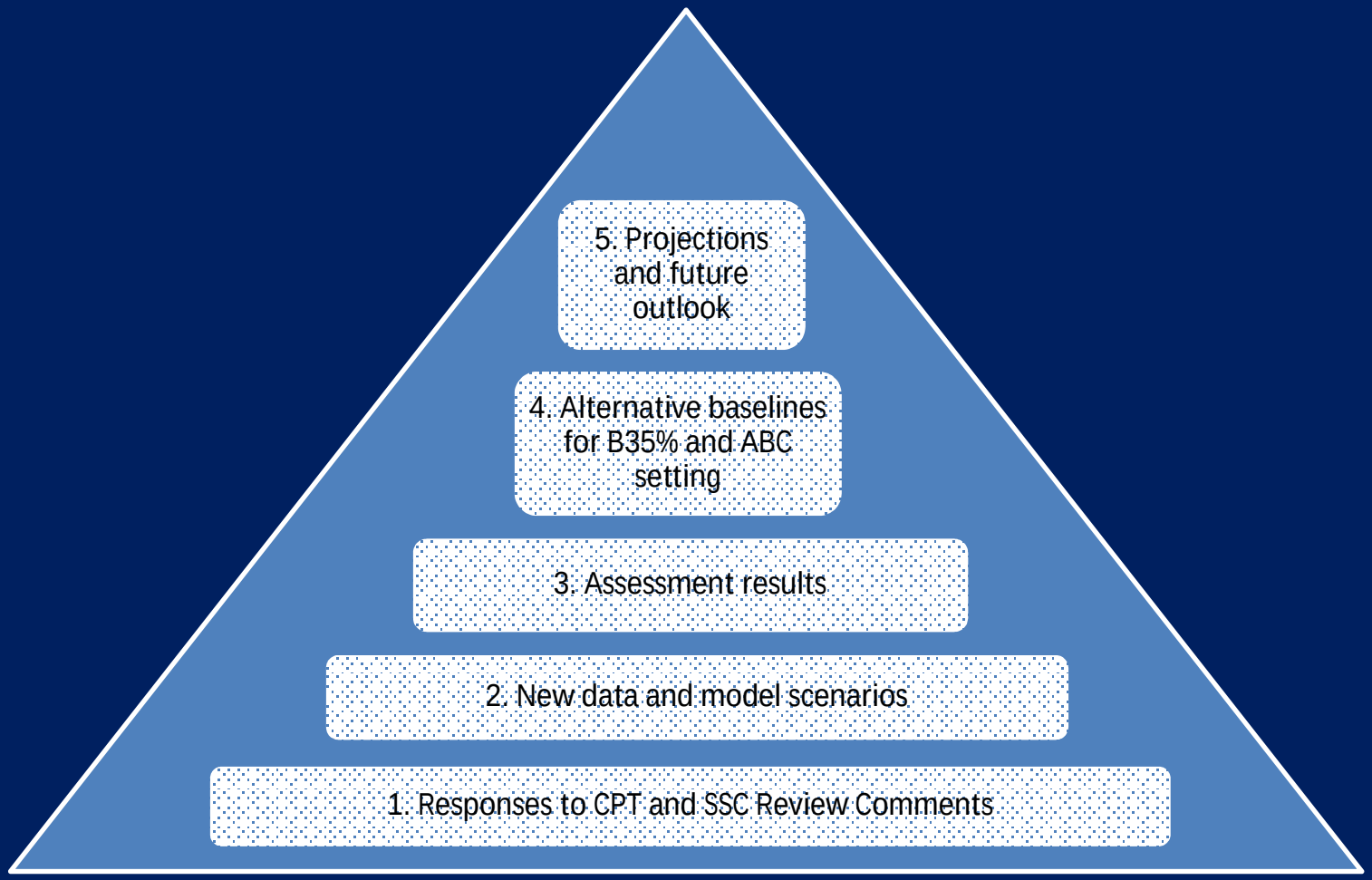
Bristol Bay Red King Crab Assessment in Fall 2016

J. Zheng and M.S.M. Siddeek

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 2015)

"The CPT recommends that size composition and biomass estimates from the 2013-2015 BSFRF side-by-side surveys be included in the assessment model. Sufficient data from these surveys are now available to help inform catchability of the NMFS trawl survey. The CPT identified several approaches, such as considering these surveys as an extension of the BSFRF surveys in 2007 and 2008, which are already used in the model. The earlier surveys did not use the side-by-side design, so technical aspects considerations of this approach would need to be evaluated. Another approach would be to drop the 2007 and 2008 surveys, and to add the 2013-2015 surveys. Since size composition data were collected during 2013-2015 surveys, it should be possible to evaluate survey selectivity, which needed to be assumed for 2007-2008 surveys. Due to the amount of analysis required to incorporate a new survey time series into the model, Jie did not think that this would be ready for review at the May 2016 CPT meeting."

Response: These comments were addressed in May 2016.

Response to CPT Comments

Response to CPT Comments (from January 2016):

"CPT requests to the Bristol Bay red king crab assessment authors for May 2016 meeting: The CPT requested two assessments in which data from the 2007 and 2008 BSFRF surveys and the 2013–2015 BSFRF side-by-side are used to estimate trawl survey selectivity using the aforementioned snow crab model "separate survey" approach: one assessment without a prior for survey Q from the Otto-Somerton double-bag study; one assessment with a prior for survey Q from the double-bag study. The CPT also recommended that an approach be developed where the paired design of 2013-2015 BSFRF surveys is used to directly estimate selectivity. This would involve adding size-structured tow-by-tow data in new likelihood component in the assessment model, and was considered as a project for model development. There was no expectation by the CPT that such a model would be a candidate base model for review at the May CPT meeting."

Response: These comments were addressed in May 2016.

Response to CPT Comments

Response to CPT Comments (from May 2016):

"The CPT had several comments about this approach. First, it was noted at NMFS/BSRF ratios were highly variable, and that a better approach would be to consider the ratio of the NMFS survey to the sum of two surveys NMFS/(NMFS+BSFRF). Second, an attempt should be made to fit actual tow-by-tow data rather than survey aggregates. Finally, catchability for the NMFS survey was estimated to be greater than one for some model runs (this only occurred when the prior was omitted).It was suggested that catchability could be limited to values less than one by parameterizing catchability on a logit scale. The CPT concluded that these issues needed to be addressed before scenario 3 could be adopted."

Response: the ratio of the NMFS survey to the sum of two surveys NMFS/(NMFS+BSFRF) was also evaluated in May 2016 and the results were not presented to the CPT meeting but were added to the final draft report. We agree that this approach is better than the NMFS/BSRF ratios.

Due to very small amount of crab caught in each tow, it is not feasible to fit the actual tow-by-tow data.

We will examine the approach to parameterize catchability on a logit scale so that it is less or equal to 1.0 in the future work (May 2017).

"The CPT requests that the following models be brought forward in September 2016: scenario 1 (status quo), scenario 1n, and scenario 2. Since results from the 2016 BSFRF survey will be available on the same timetable as the 2016 NMFS survey, these data should be incorporated into scenarios 1n and 2."

Response: *These three scenarios are presented in the September 2016 SAFE report.*

Response to SSC Comments

Response to SSC Comments specific to this assessment (from October 2015):

"The SSC reiterates its previous concern that improvement in model fit by increasing M is not a sufficient condition for accepting Model 1. The SSC reiterates its previous recommendation that the author should test the hypothesis that natural mortality varies annually due to environmental change by running a research model with a random walk on M and then statistically evaluating relationships between time trends in estimated M relative to plausible mechanisms influencing M. We agree that this model should not be used for setting biological reference points, however it may provide useful information on the appropriate time stanzas for time varying M. Mechanistic explanations for the resulting time stanzas could then be explored.

The SSC agrees with the CPT that the author should explore a model that incorporates the 2013-2015 side-by-side BSFRF data."

Response: The side-by-side data were evaluated in May 2016. We have spent considerable time over last 20 years to identify mechanisms for change in natural mortality over time but without much success. It is a very complex problem and many factors might have played a role on it. We will continue to work on this issue in the future.

Response to SSC Comments

Response to SSC Comments specific to this assessment (from June 2016):

"The SSC supports the CPT recommendation to bring forward three scenarios for the stock assessment in fall 2016: (1) scenario 1, which is the status quo (2015) using BSFRF data from 2007 ad 2008 in which the two surveys are treated as independent surveys and survey selectivities are estimated separately and directly in the model; (2) scenario 1n, which is the same as scenario 1 but also includes the 2013-2015 BSFRF survey data, and (3) scenario 2, which is the same as scenario 1n but assumes that the BSFRF survey has capture probabilities of 1.0 for all length groups.

When these scenarios are presented, the terms "capture probabilities" and "selectivity" should be clearly defined. In the report, their descriptions seemed somewhat confusing and contradictory. For instance, Figure 6 implies catchabilities at small sizes in the BSFRF survey that are less than 1.0 for all scenarios, but from the text, this should not be the case. It is important that the definitions and procedures are clearly described."

Response: We reported the results of these three scenarios in this SAFE report and cleaned up the confusion of terms "capture probabilities" and "selectivity" throughout the report.

Summary of Major Changes in 2016

1. Changes to the input data:
   a. The new 2016 NMFS trawl survey data and BSFRF side-by-side trawl survey data during 2013-2016 were used.
   b. Catch and bycatch data were updated with 2016 data.
   c. Total NMFS survey biomass CVs were updated and they are slightly different from those in 2015 for some years.

Summary of Major Changes in 2015

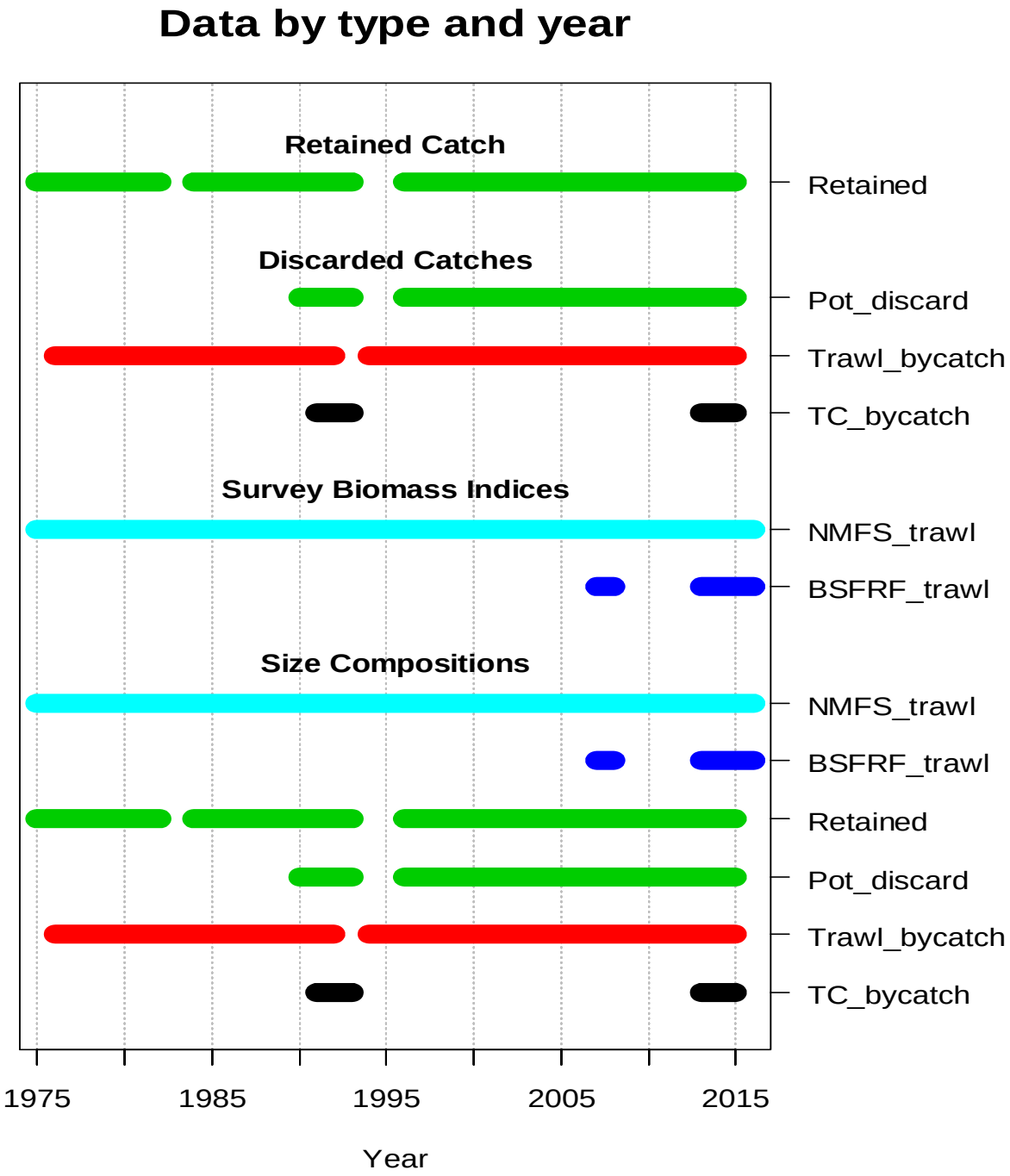
2. Changes to the assessment methodology:

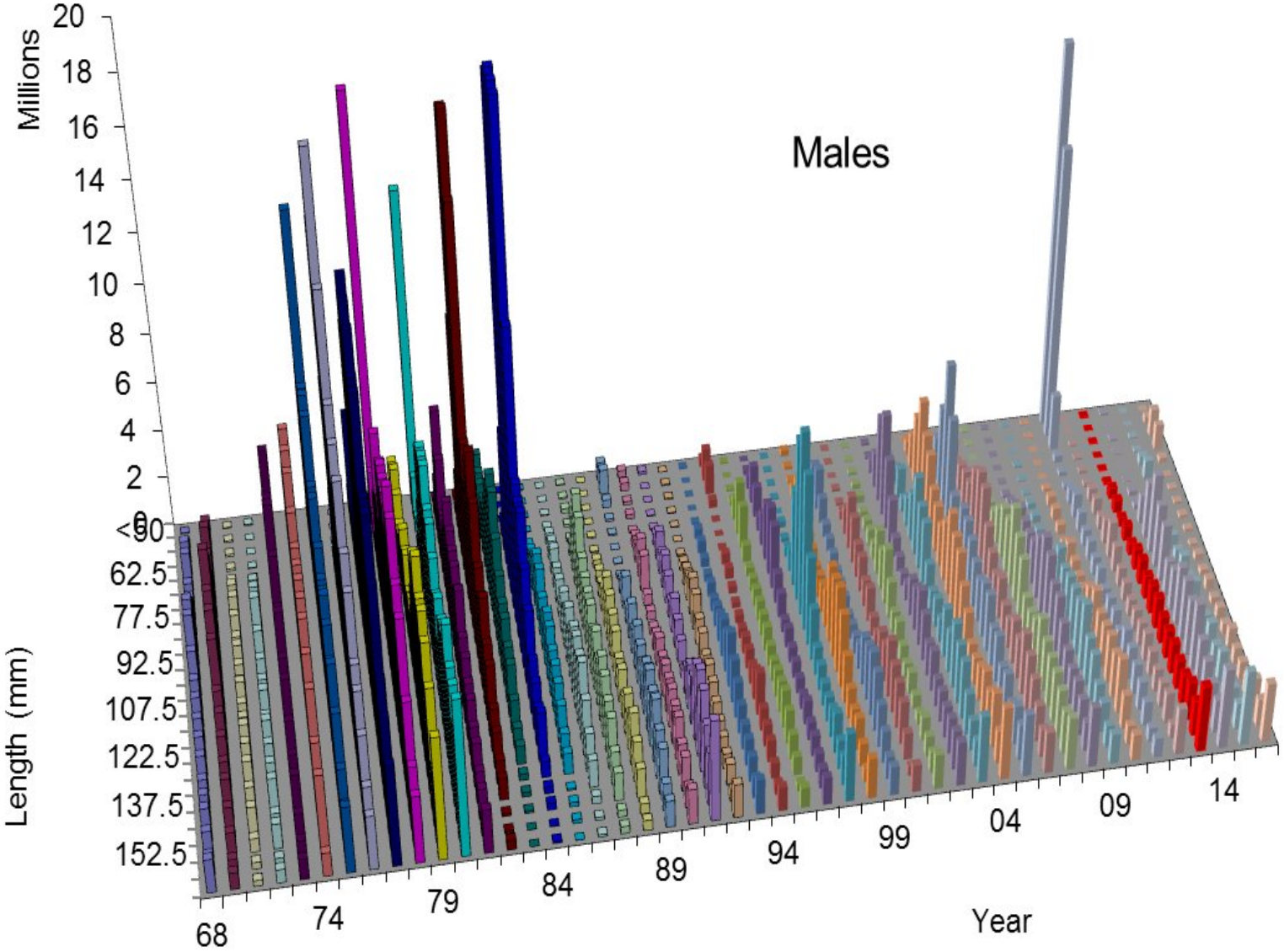
Three model scenarios are evaluated in this report:

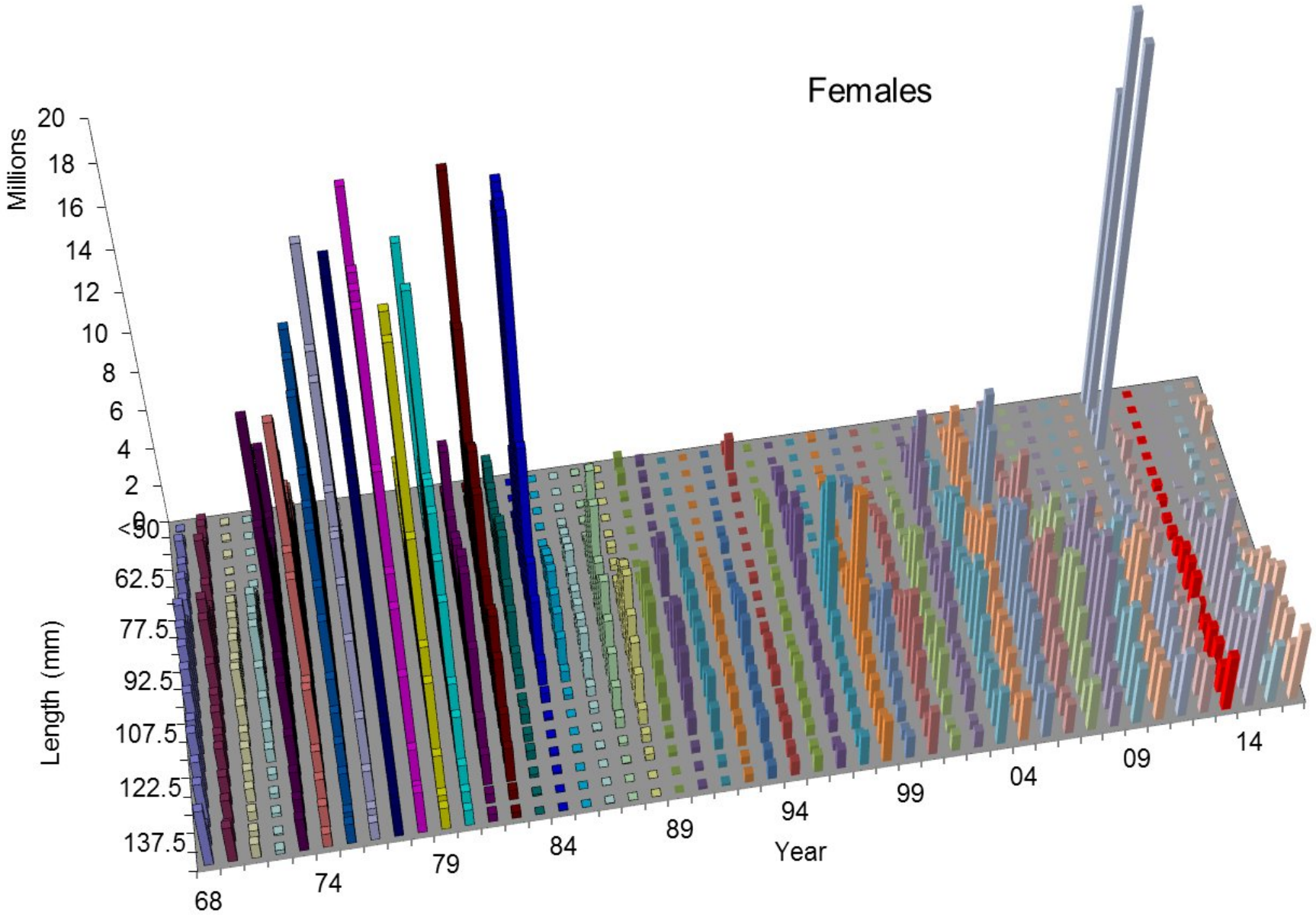
Scenario1: the same as Scenario 1 in the SAFE report in September 2015 using BSFRF survey data in 2007 and 2008. The BSFRF survey is treated as an independent survey, and no assumption is made about the capture probabilities of the BSFRF survey. In effect, survey selectivities for both surveys are estimated separately and directly in the model.

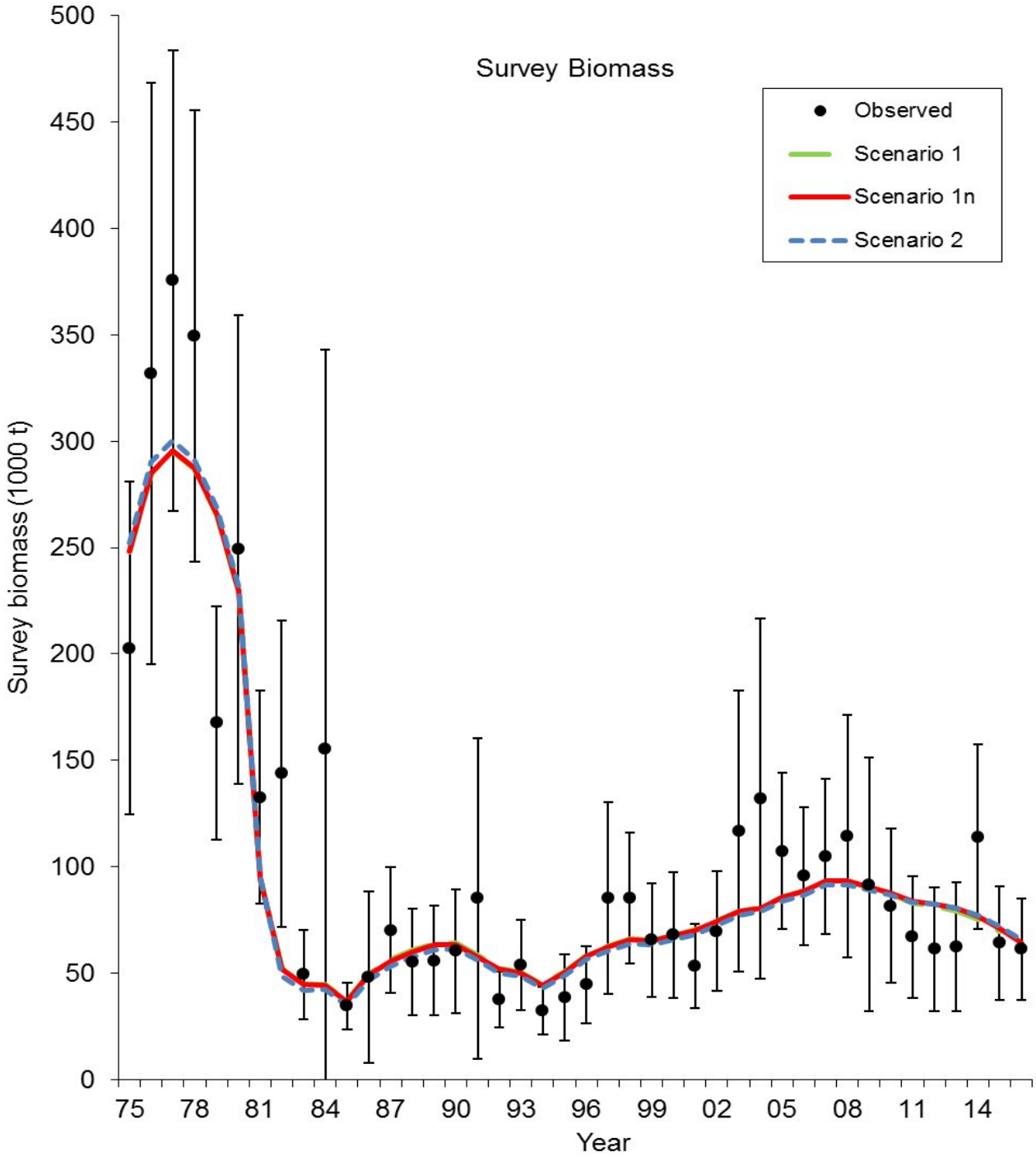
Scenario 1n: the same as scenario 1 plus additional BSFRF survey data in 2013-2016.

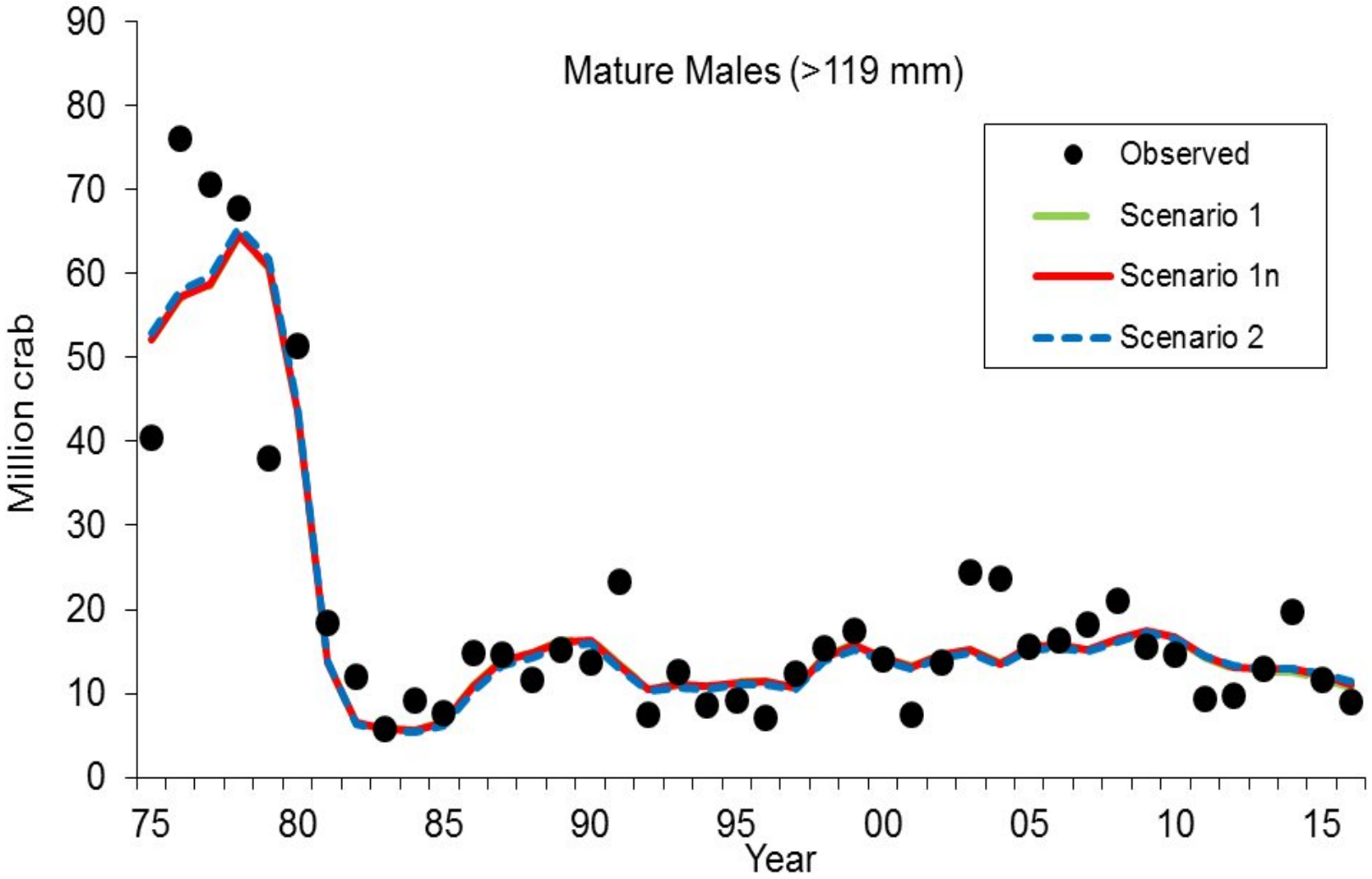
Scenario 2: the same as scenario 1n except for the assumption that BSFRF survey capture probabilities are 1.0 for all length groups. Under this assumption, NMFS survey selectivities are the products of crab availabilities (equal to BSFRF survey selectivities) and NMFS survey capture probabilities.

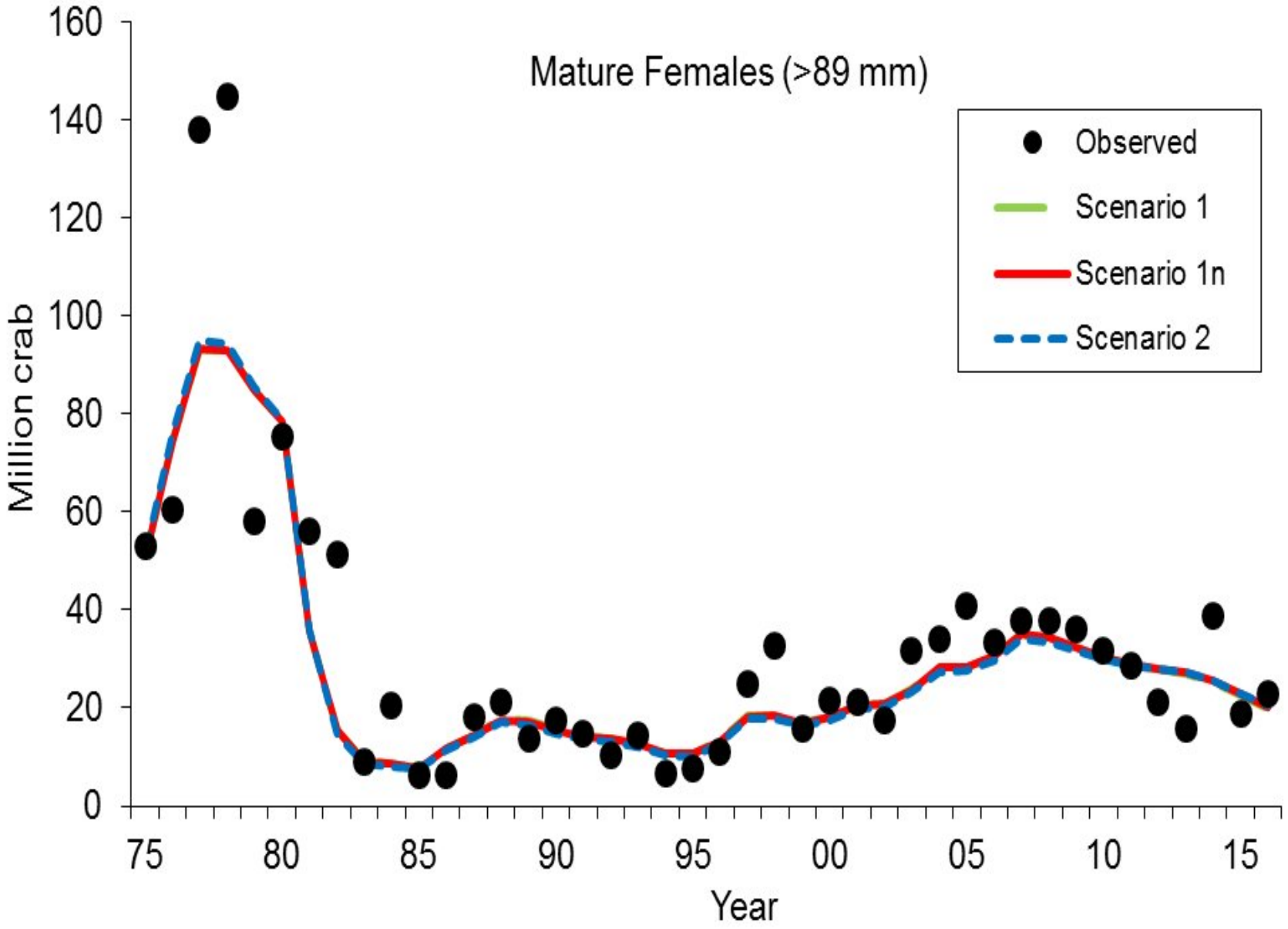

Data by type and year
Retained Catch
Retained
Discarded Catches
Pot_discard
Trawl_bycatch
TC_bycatch
Survey Biomass Indices
NMFS_trawl
BSFRF_trawl
Size Compositions
NMFS_trawl
BSFRF_trawl
Retained
Pot_discard
Trawl_bycatch
TC_bycatch
1975
1985
1995
2005
2015
Year

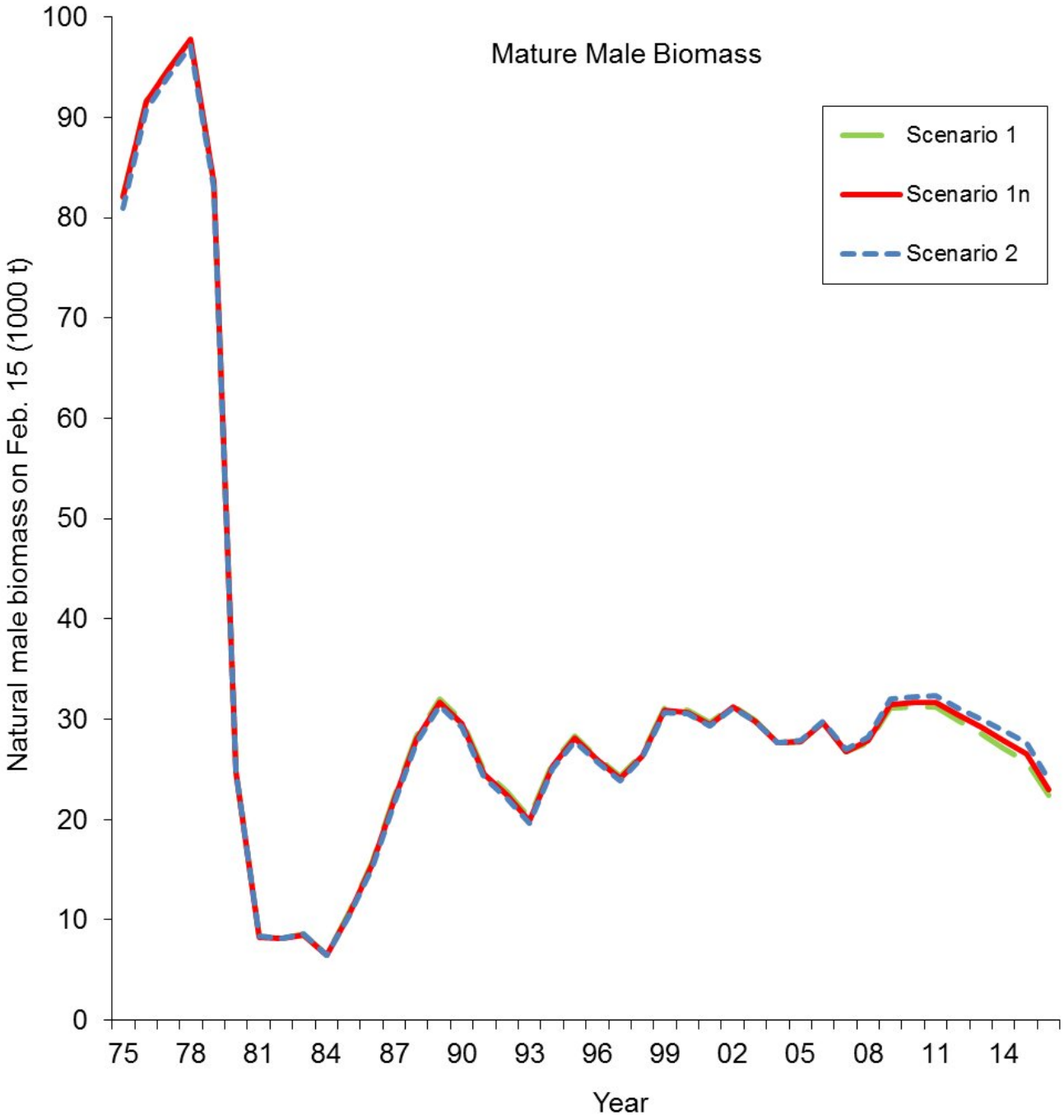

Males
Millions
20
18
16
14
12
10
8
6
4
2
0
Length (mm)
<60
62.5
77.5
92.5
107.5
122.5
137.5
152.5
68
74
79
84
89
94
99
04
09
14
Year

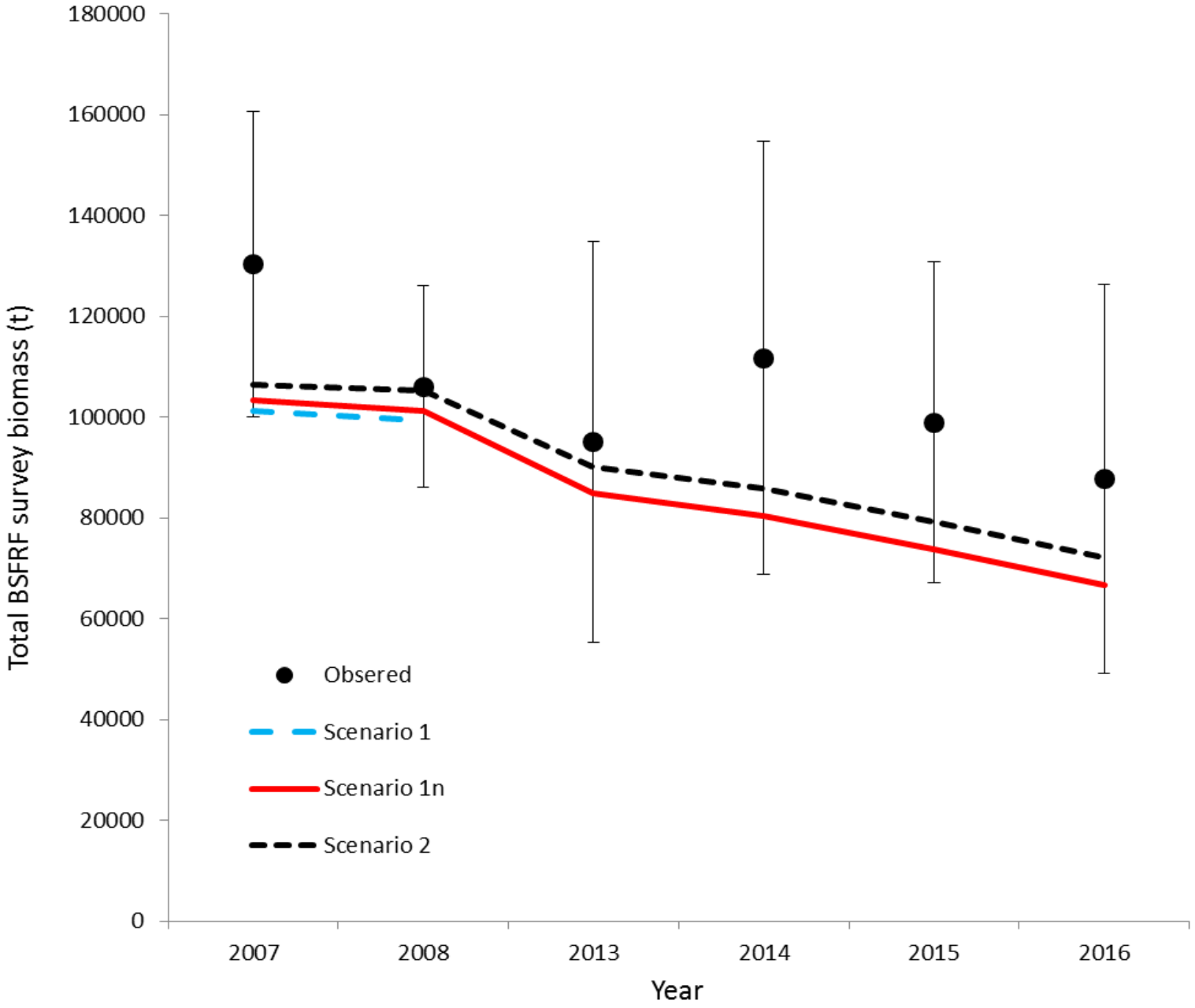

Females
Millions
20
18
16
14
12
10
8
6
4
2
0
Length (mm)
<50
62.5
77.5
92.5
107.5
122.5
137.5
68
74
79
84
89
94
99
04
09
14
Year


Survey Biomass
Observed
Scenario 1
Scenario 1n
Scenario 2
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
Year


Mature Males (>119 mm)
Observed
Scenario 1
Scenario 1n
Scenario 2
Million crab
0
10
20
30
40
50
60
70
80
90
75
80
85
90
95
00
05
10
15
Year

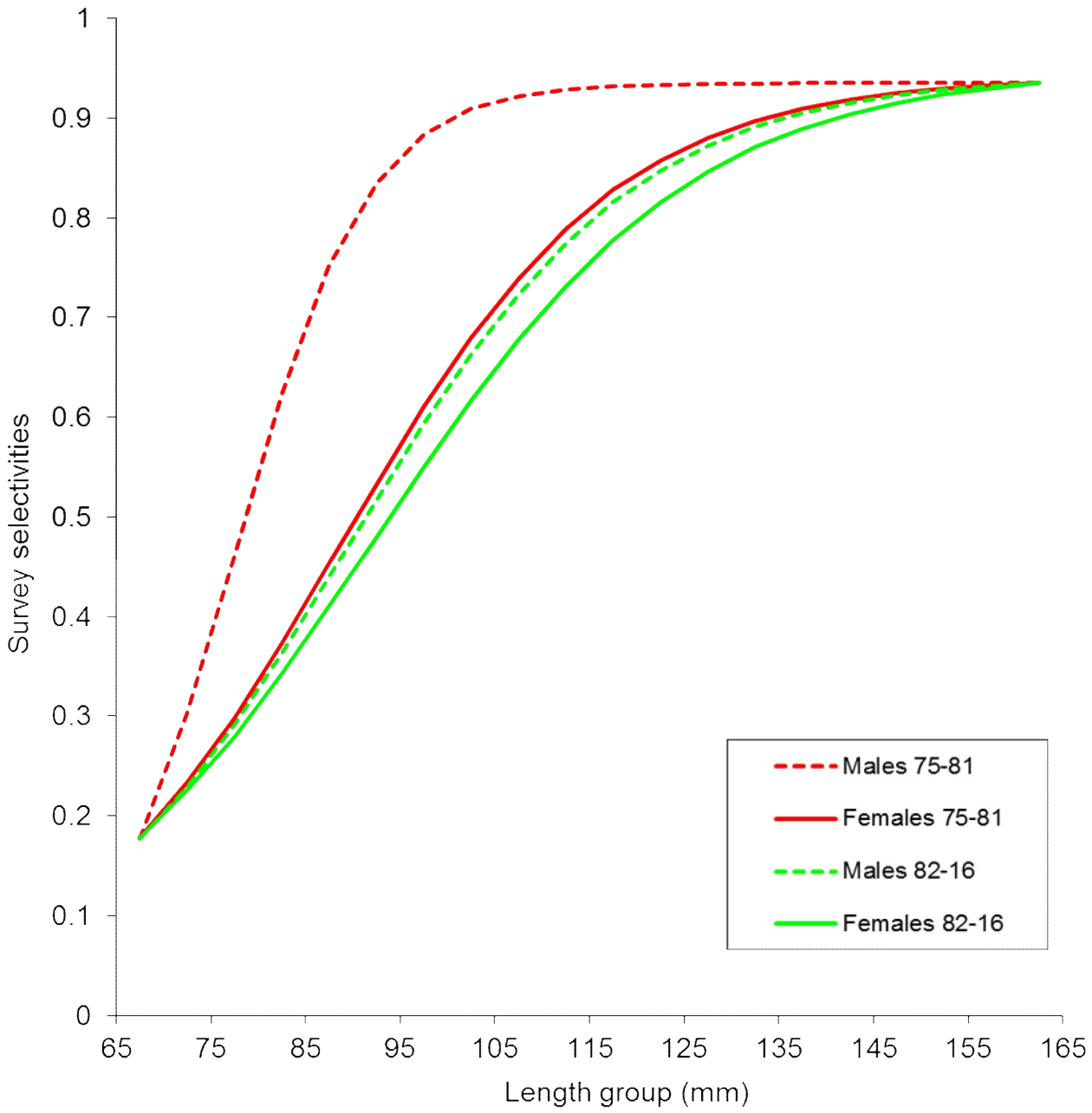

Mature Females (>89 mm)
Observed
Scenario 1
Scenario 1n
Scenario 2
Million crab
160
140
120
100
80
60
40
20
0
75
80
85
90
95
00
05
10
15
Year


Mature Male Biomass
Natural male biomass on Feb. 15 (1000 t)
Year
Scenario 1
Scenario 1n
Scenario 2
0
10
20
30
40
50
60
70
80
90
100
75
78
81
84
87
90
93
96
99
02
05
08
11
14

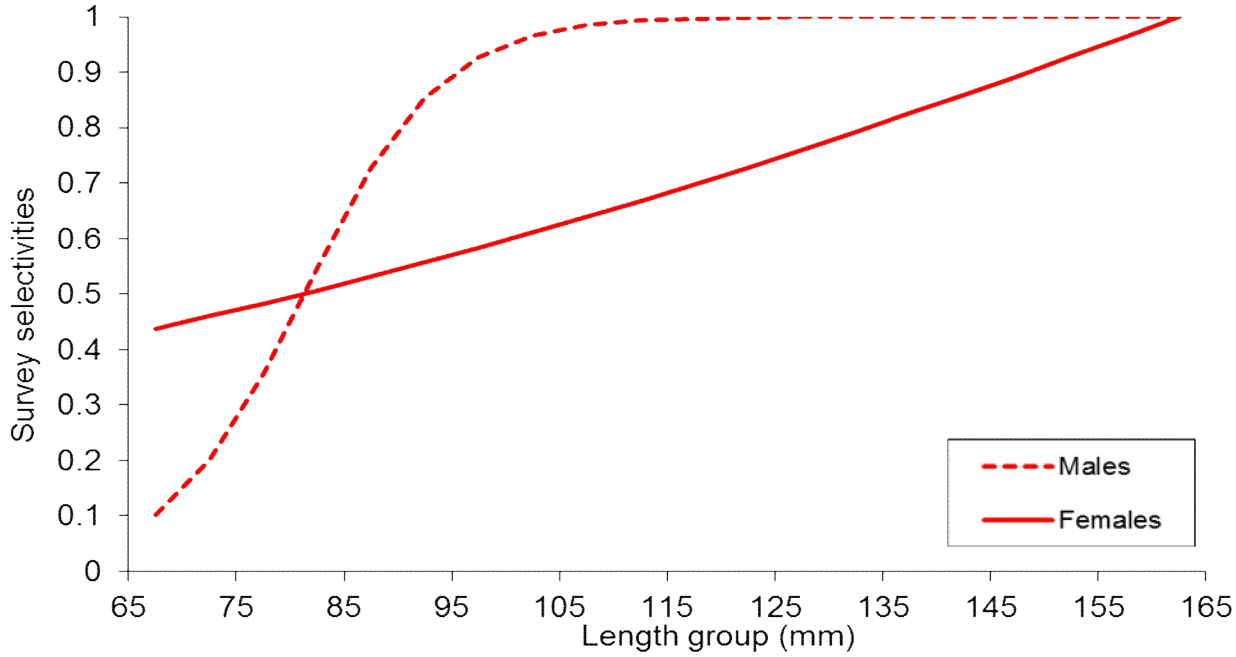

180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Total BSFRF survey biomass (t)
Obsered
Scenario 1
Scenario 1n
Scenario 2
2007
2008
2013
2014
2015
2016
Year

	Scenario					
Negative log likelihood	1	1n	2	1 – 1n	1 - 2	1n – 2
R-variation	89.21	88.59	86.87	0.63	2.34	1.72
Length-like-retained	-1006.52	-1006.30	-1005.17	-0.22	-1.35	-1.13
Length-like-discmale	-1047.63	-1047.10	-1047.20	-0.53	-0.43	0.10
Length-like-discfemale	-2408.40	-2408.56	-2409.54	0.16	1.14	0.98
Length-like-survey	-47401.20	-47400.40	-47409.90	-0.80	8.70	9.50
Length-like-disctrawl	-2076.26	-2075.56	-2075.02	-0.70	-1.24	-0.54
Length-like-discTanner	-463.67	-464.55	-465.88	0.88	2.21	1.33
Length-like-bsfrfsurvey	-238.03	-650.31	-646.36	412.28	408.33	-3.95
Catchbio_retained	48.80	48.63	48.59	0.17	0.21	0.04
Catchbio_discmale	227.46	227.56	227.80	-0.11	-0.34	-0.24
Catchbio-discfemale	0.13	0.14	0.13	0.00	0.00	0.00
Catchbio-disctrawl	0.90	0.91	0.92	0.00	-0.02	-0.01
Catchbio-discTanner	0.14	0.14	0.12	0.00	0.02	0.02
Biomass-trawl survey	94.80	94.91	97.75	-0.11	-2.95	-2.84
Biomass-bsfrfsurvey	-4.62	-7.75	-8.07	3.13	3.45	0.32
Q-trawl survey	1.10	1.22	2.76	-0.12	-1.66	-1.54
Others	20.79	20.84	21.00	-0.05	-0.21	-0.16
Total	-54163.00	-54577.60	-54581.20	414.60	418.20	3.60
Free parameters	279	279	279	0	0	0

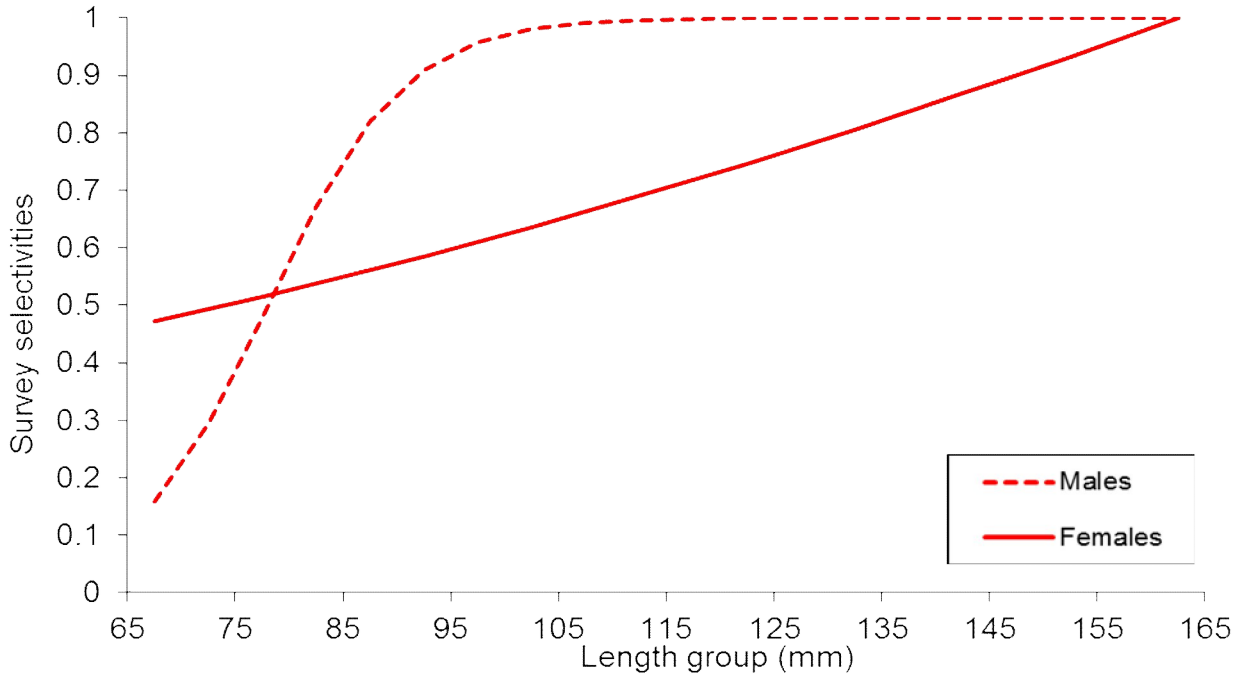
- ✓ In 2016, the survey mature male abundance is slightly less than expected while survey female abundance is higher than expected based on the survey abundances during the previous several years. The disappointment is very low estimated recruitments, which are the lowest since 1973.
- ✓ Model estimated relative survey biomasses are very similar among the three scenarios and fit the survey data quite well. The absolute population biomass estimates are slightly higher for scenario 2 than for scenarios 1 and 1n during recent years due to a slightly lower estimate of trawl survey selectivities for scenario 2 and additional BSFRF survey data for scenarios 1n and 2.
- ✓ Scenario 1n is recommended for overfishing determination this year.



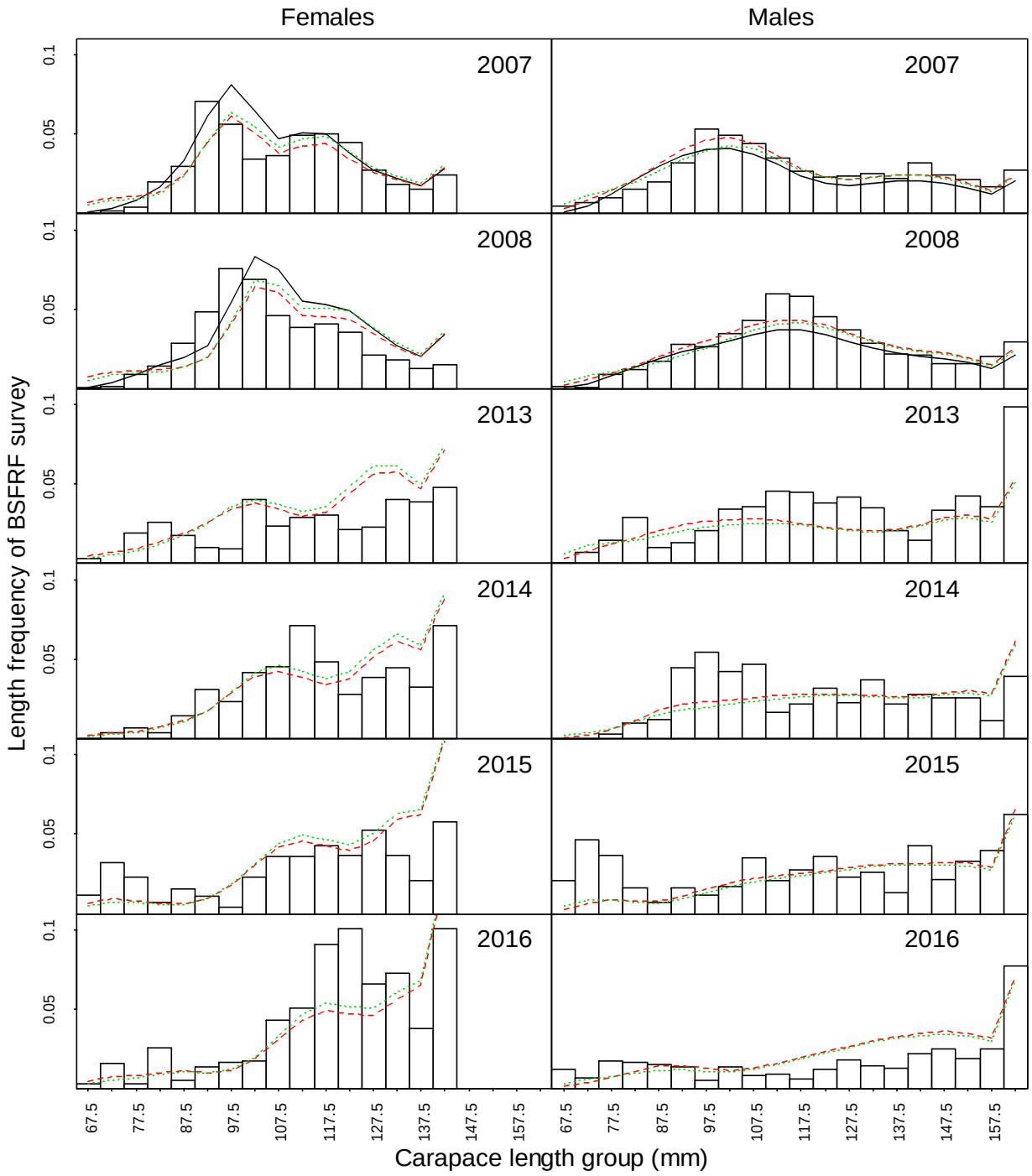
NMFS survey:
Scenario 1n



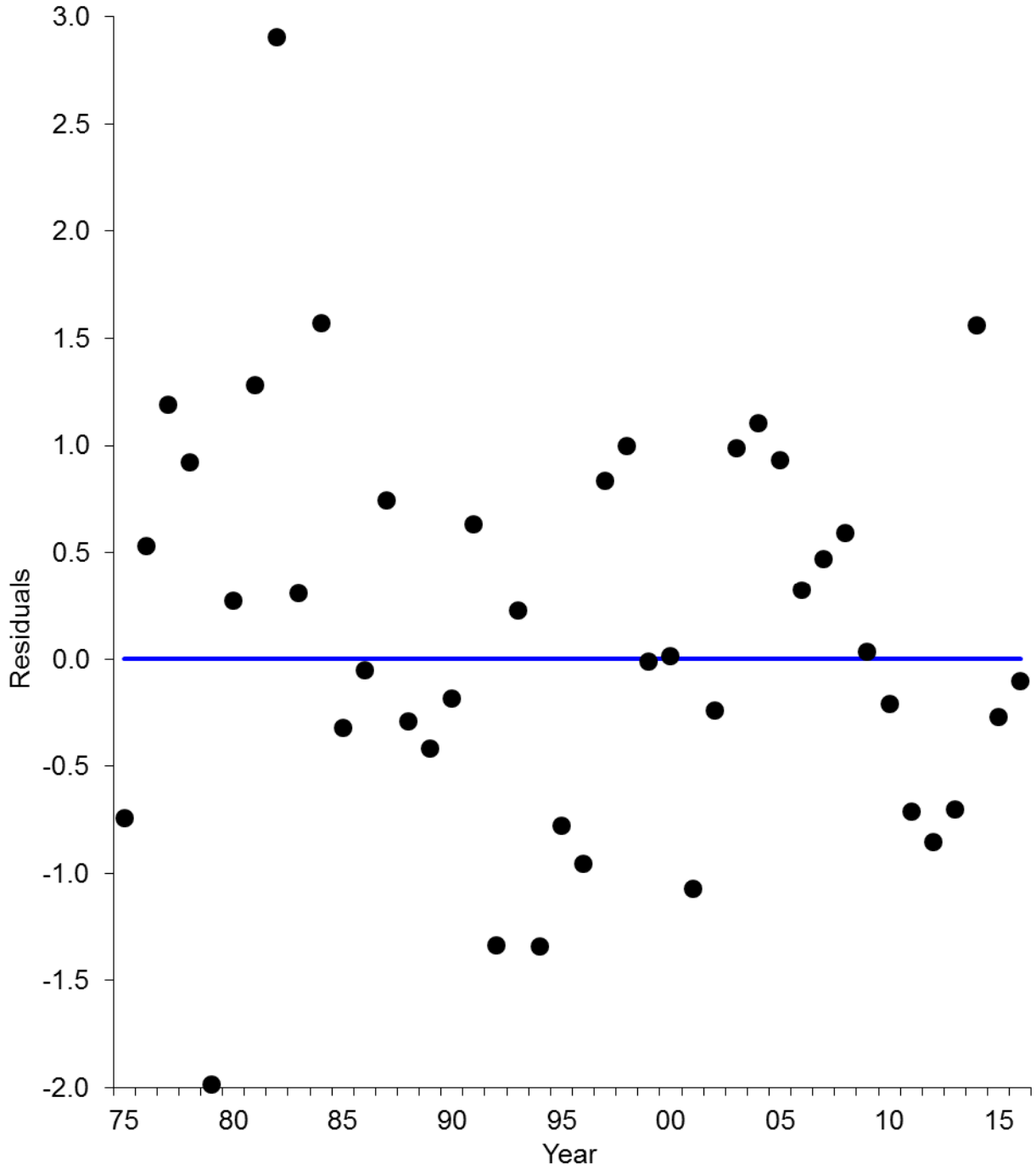
BSFRF survey: Scenario 1



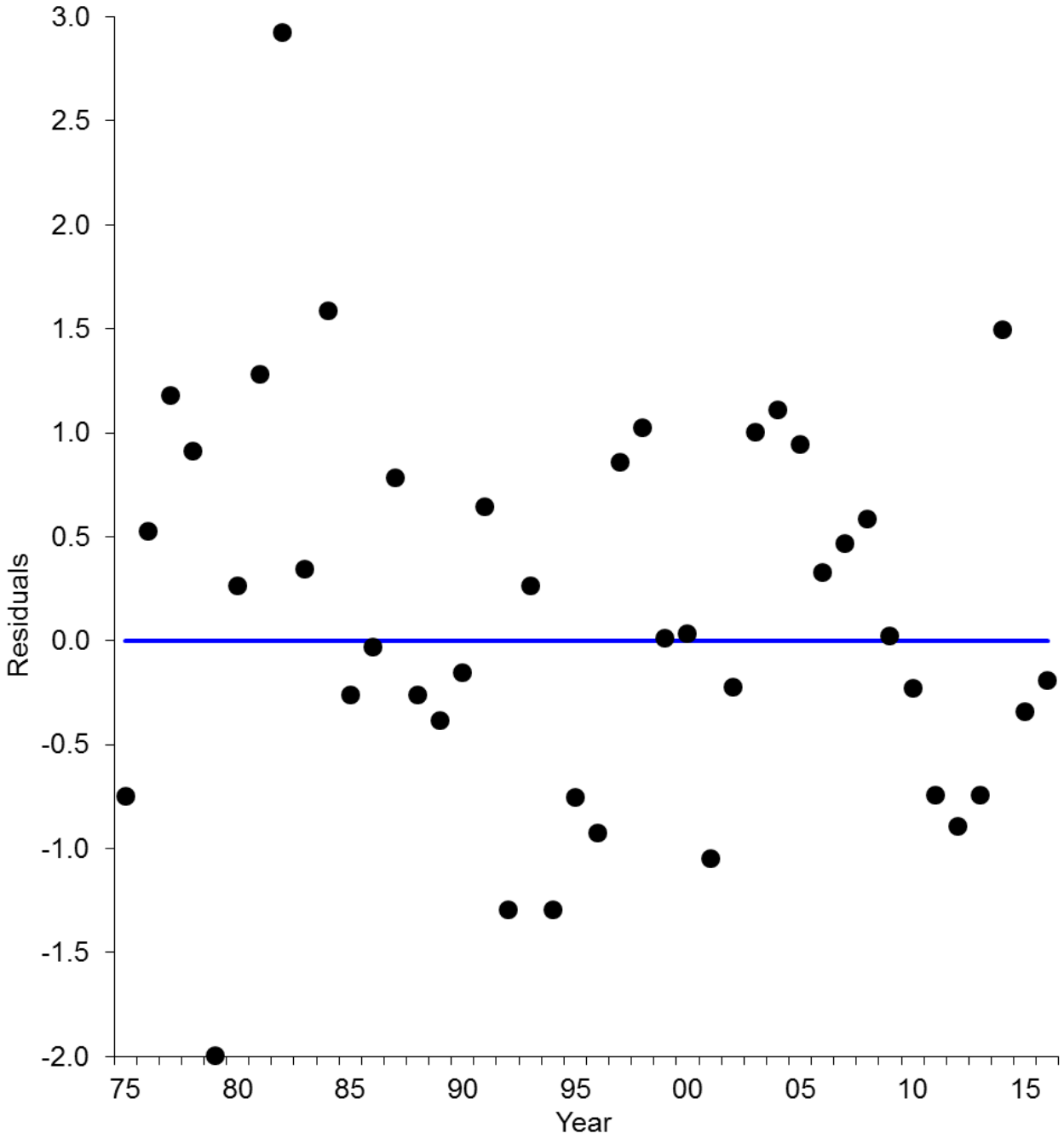
BSFRF survey: Scenario 1n



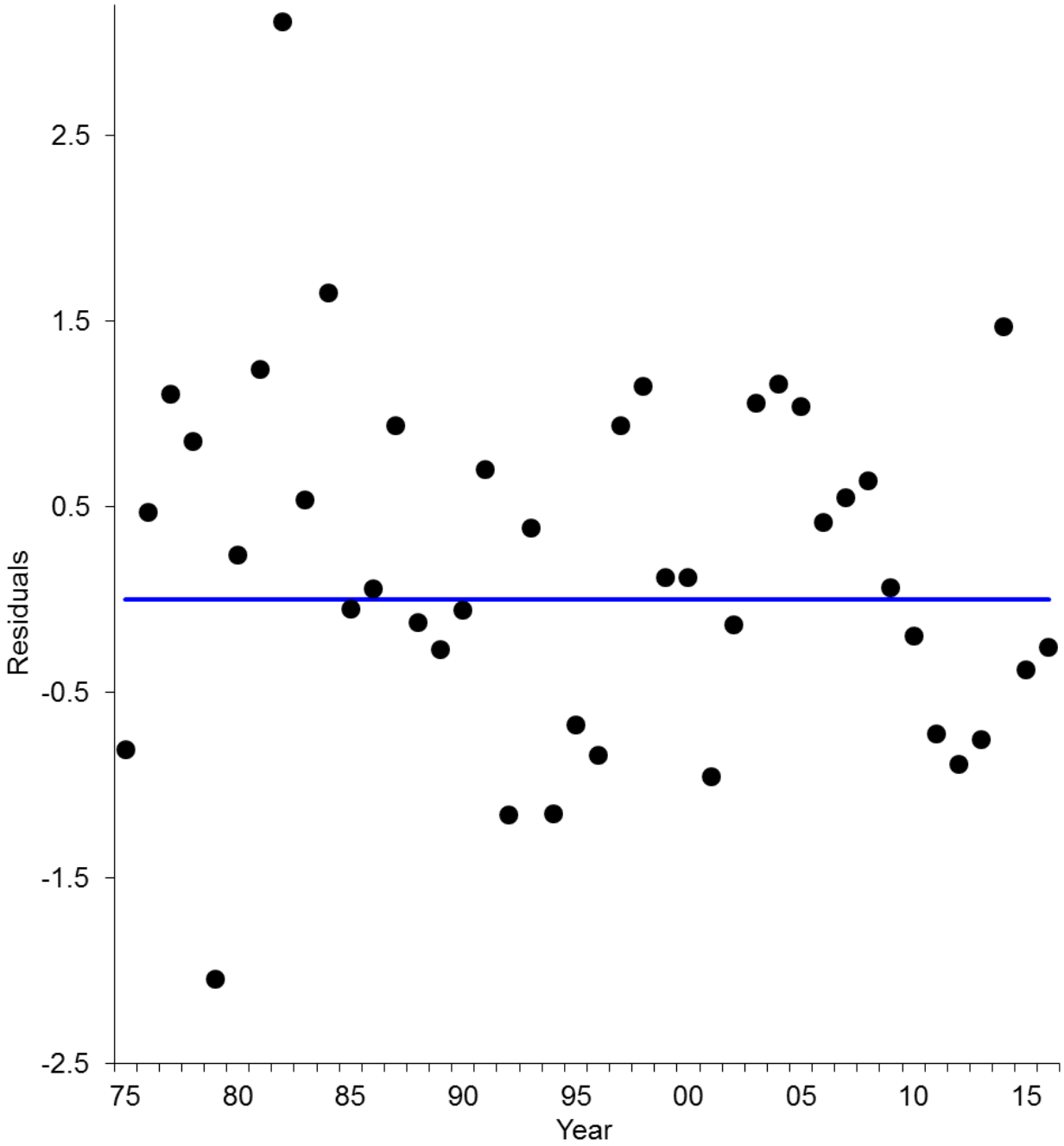
BSFRF survey length frequency. Scenarios 1 (solid black), 1n (dashed red), and 2 (green lines)



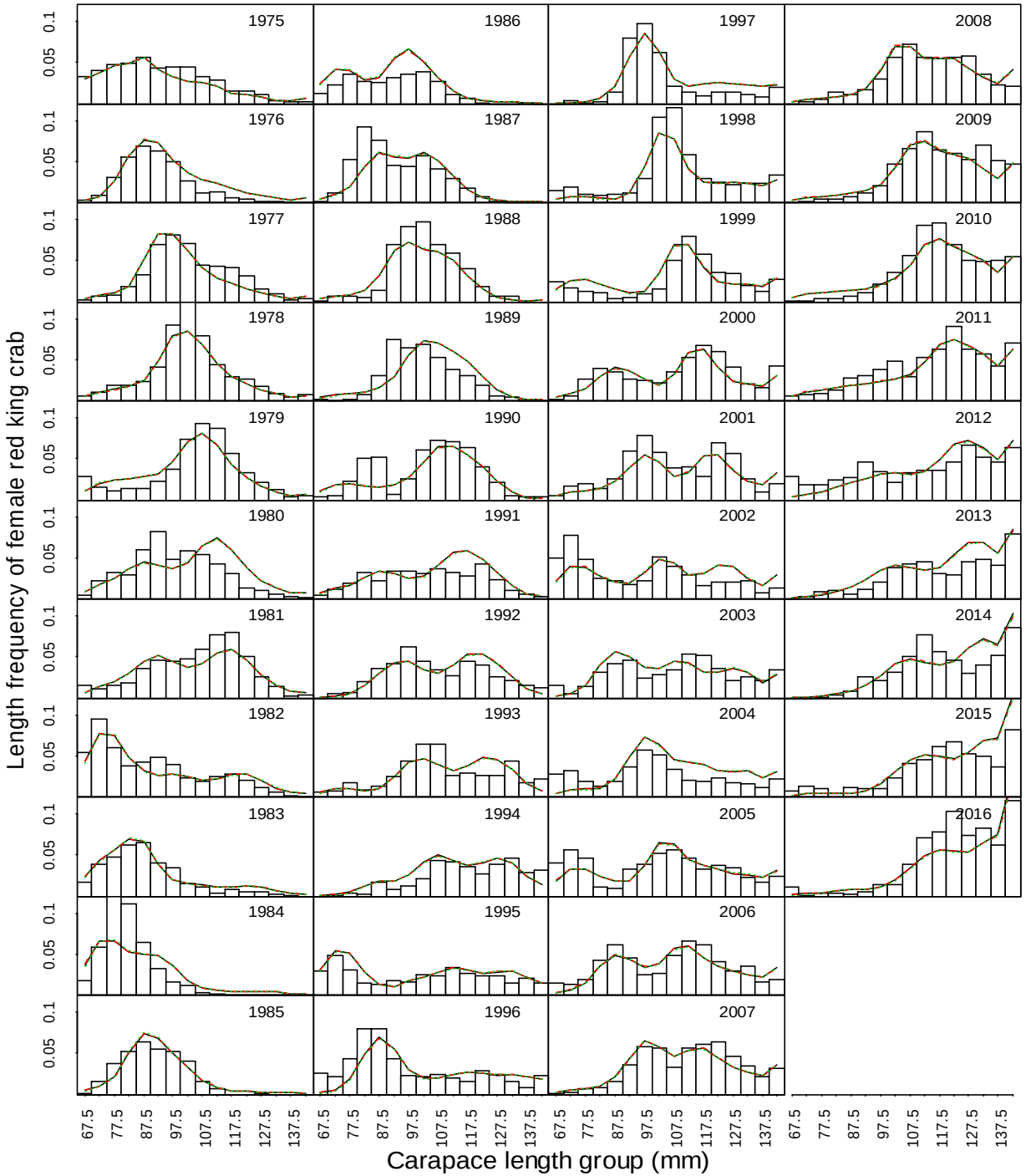
Standardized residuals of total NMFS survey biomass. Scenario 1



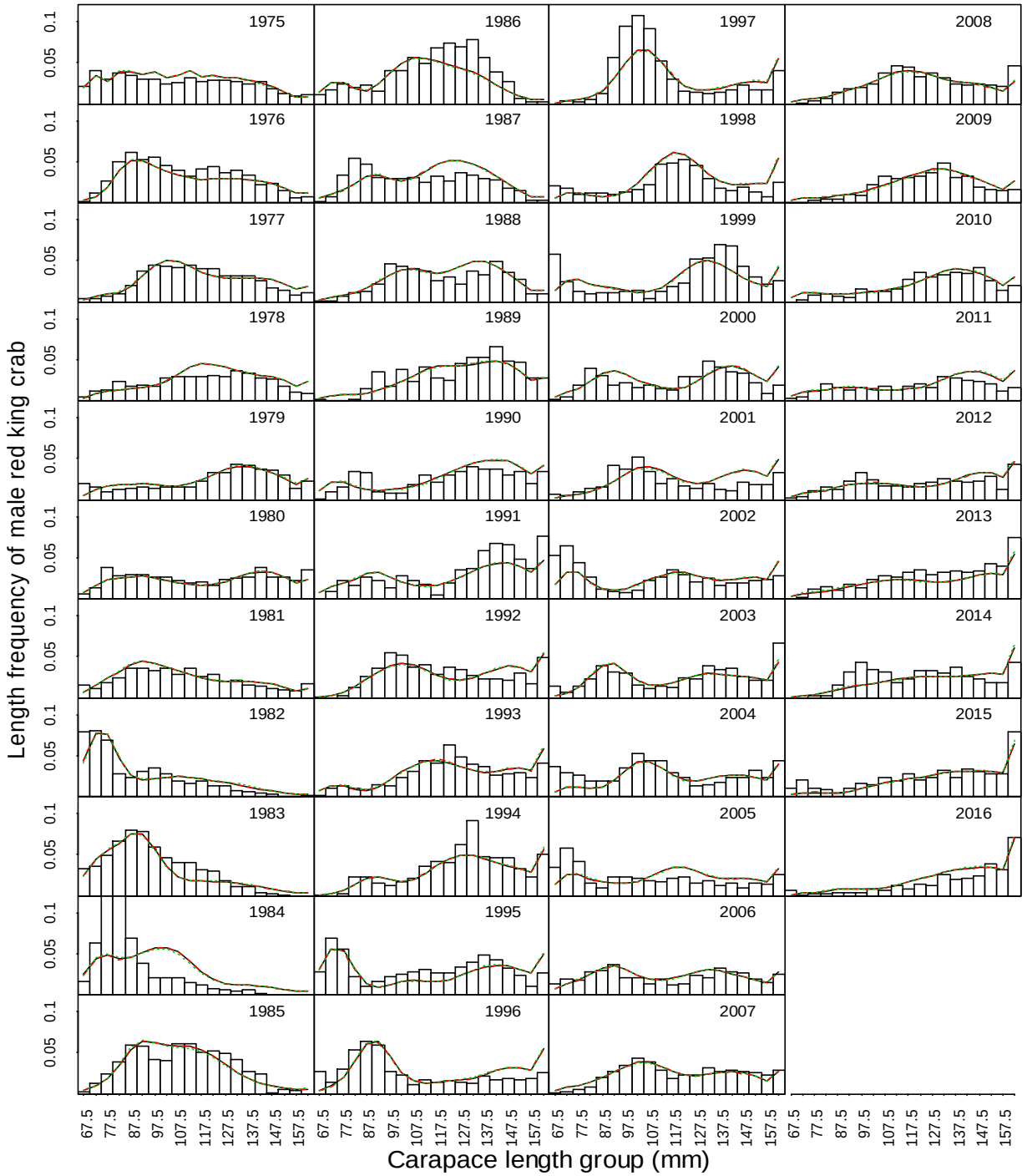
Standardized residuals of total NMFS survey biomass. Scenario 1n



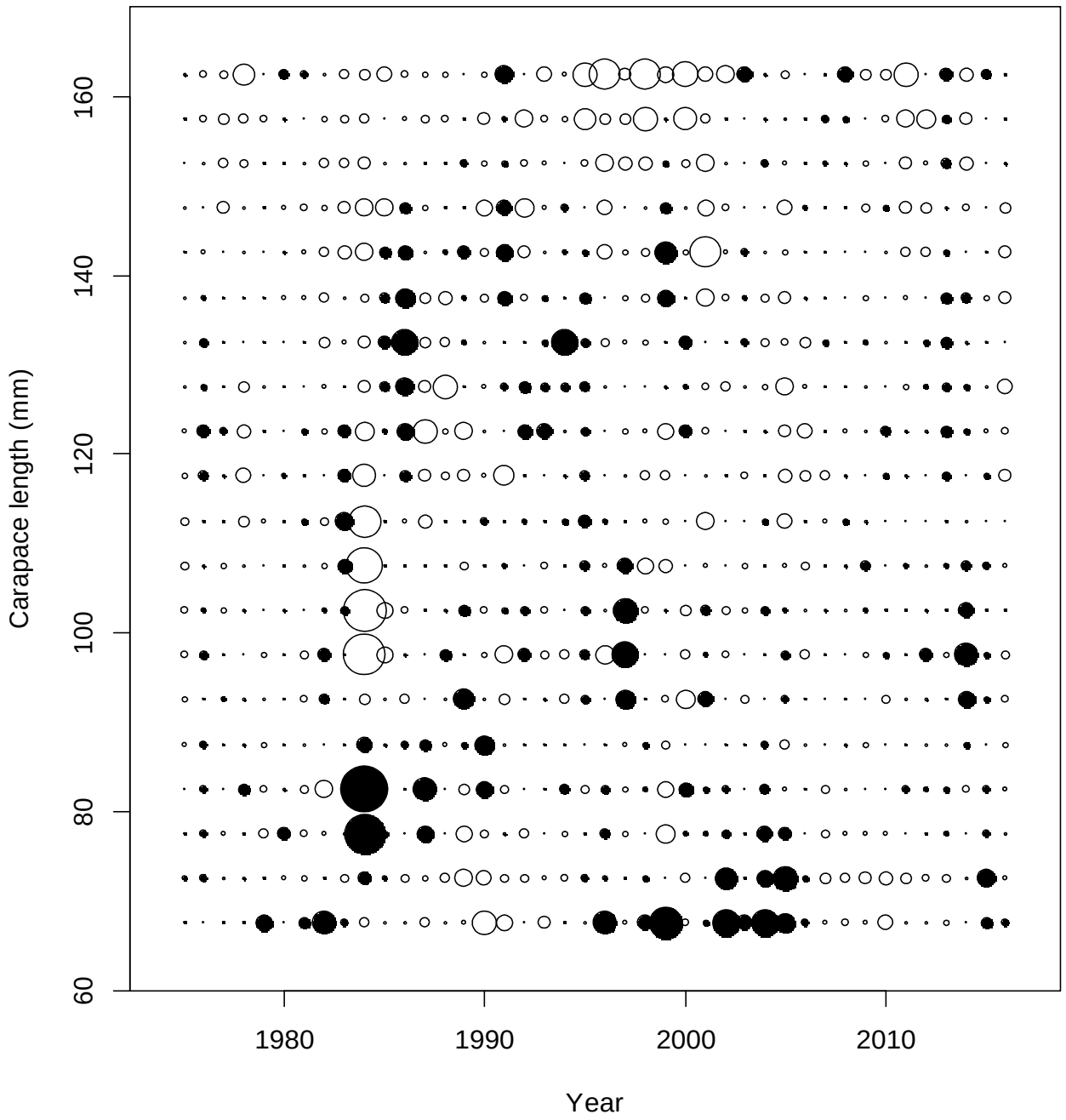
Standardized residuals of total NMFS survey biomass. Scenario 2



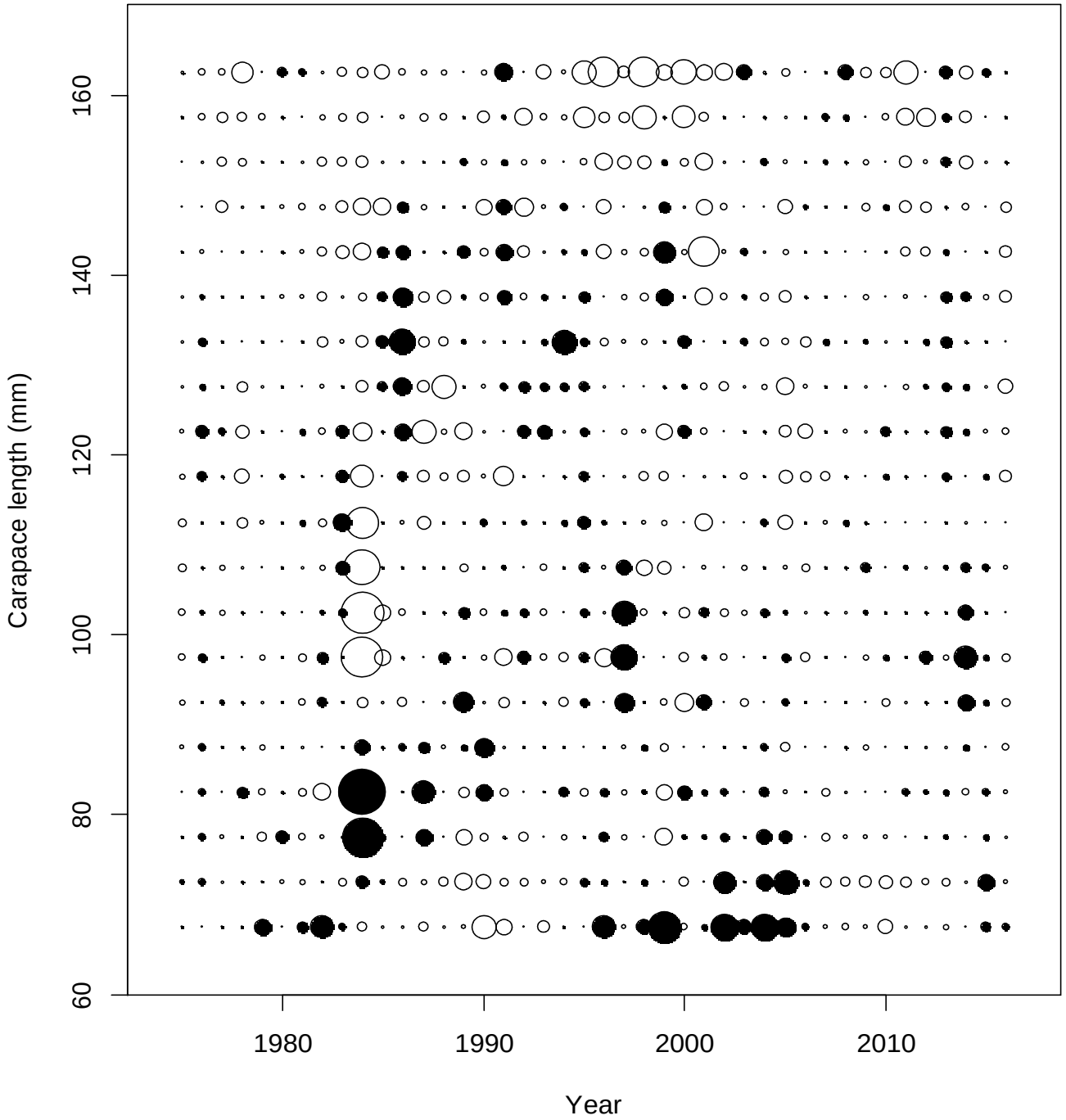
Scenarios 1(black), 1n(red), and 2(green). Males



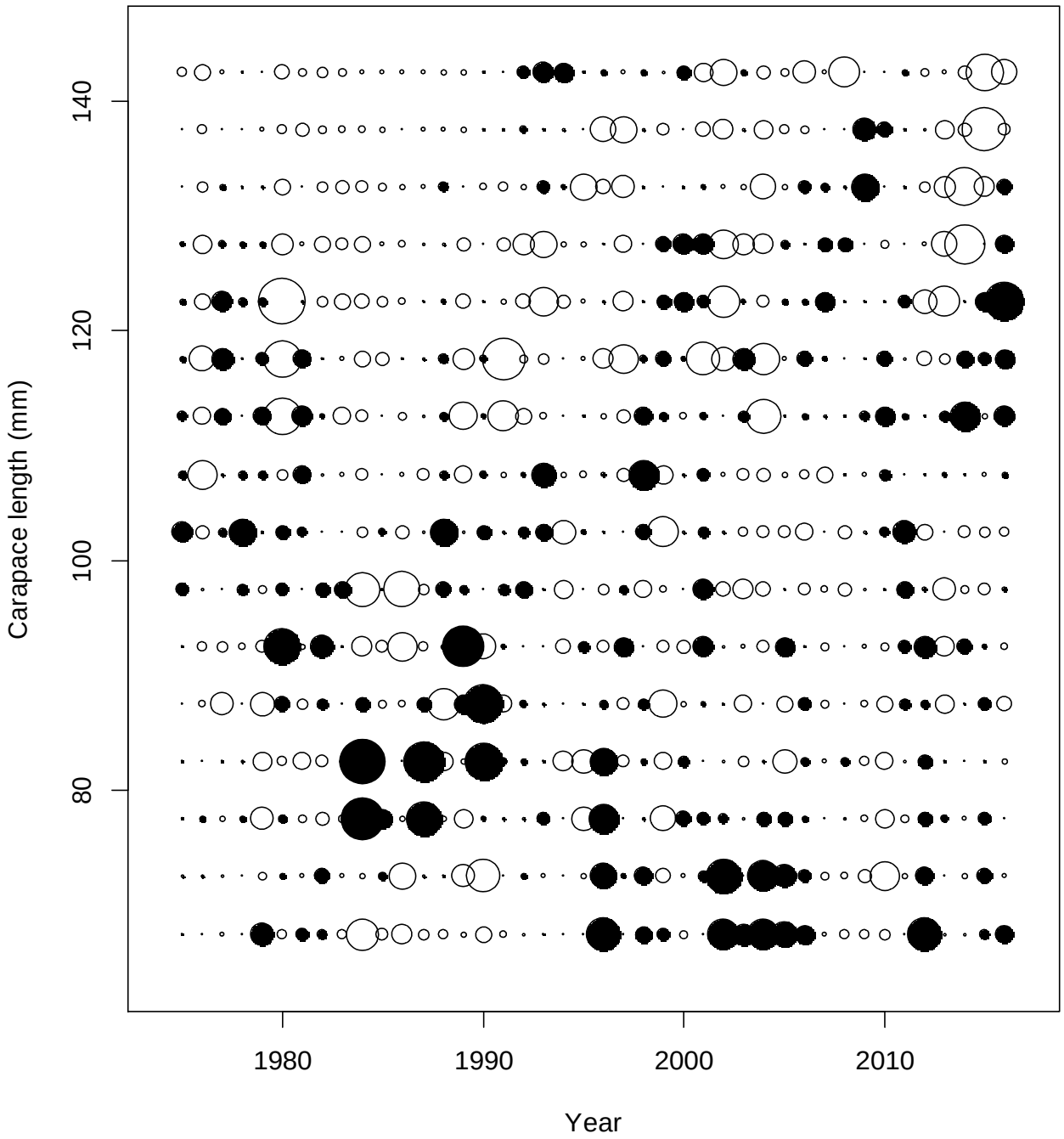
Scenarios 1(black), 1n(red), and 2 (green). Females



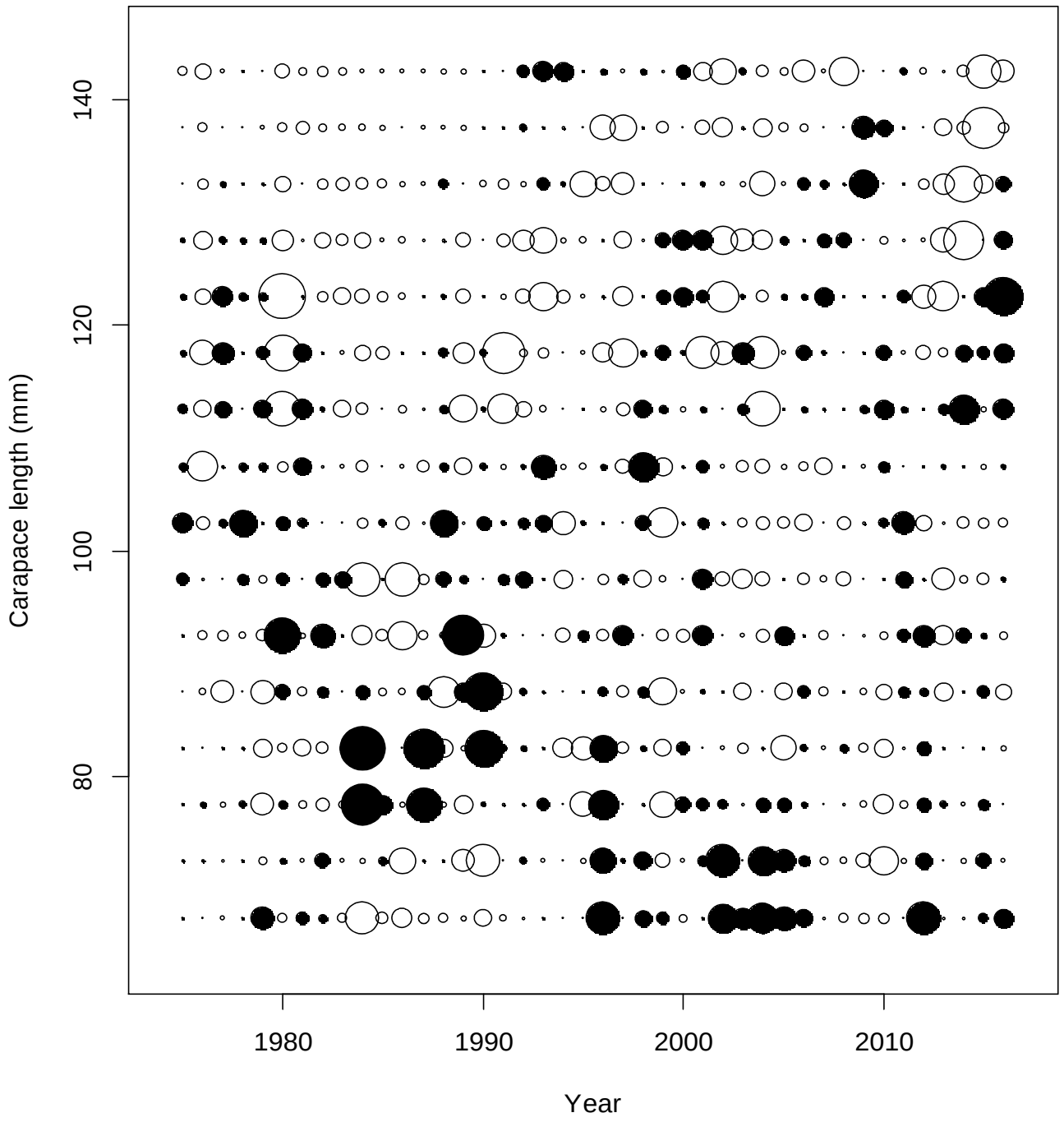
Scenario 1
Males



Scenario 1n
Males

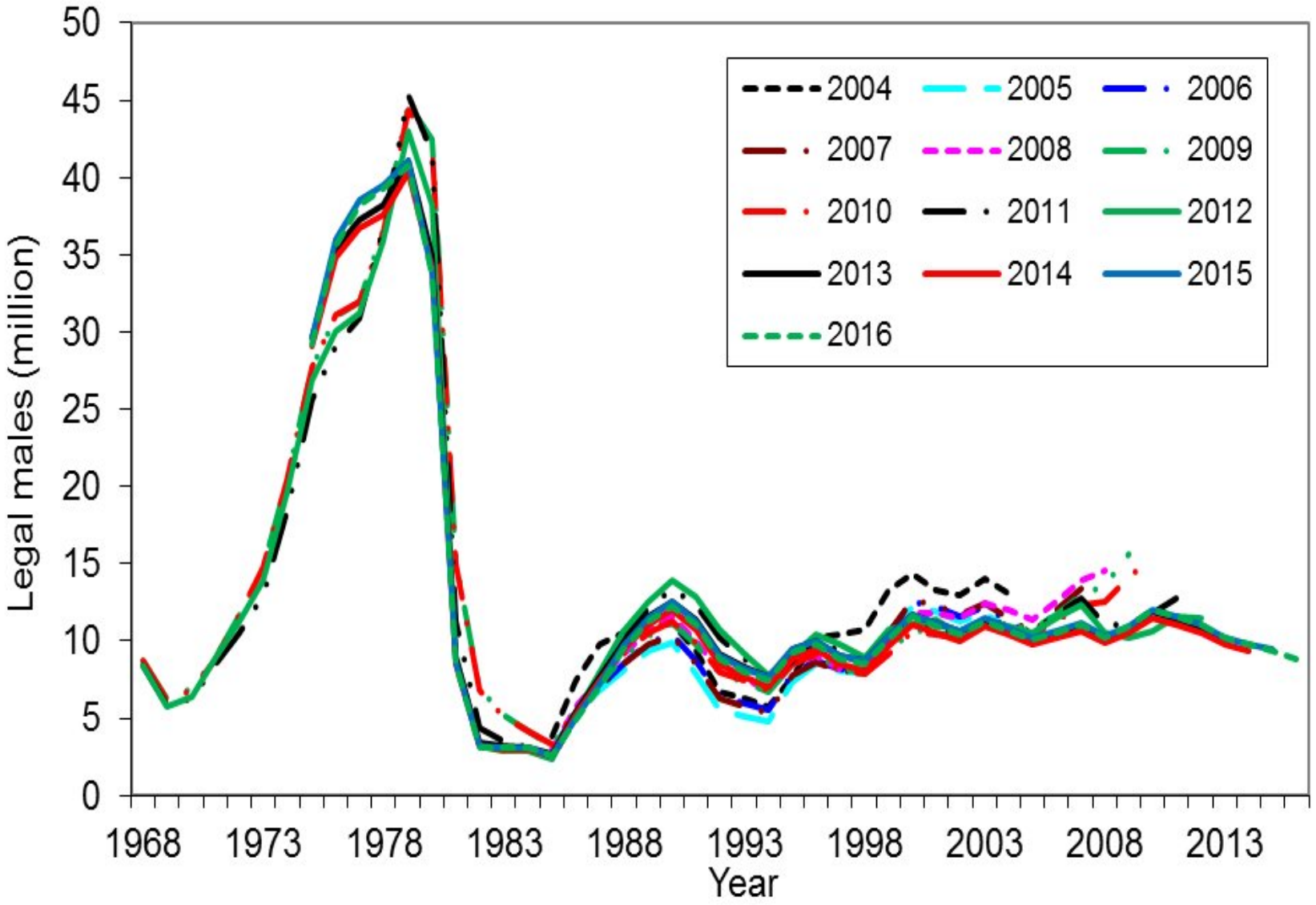


Scenario 1
Females

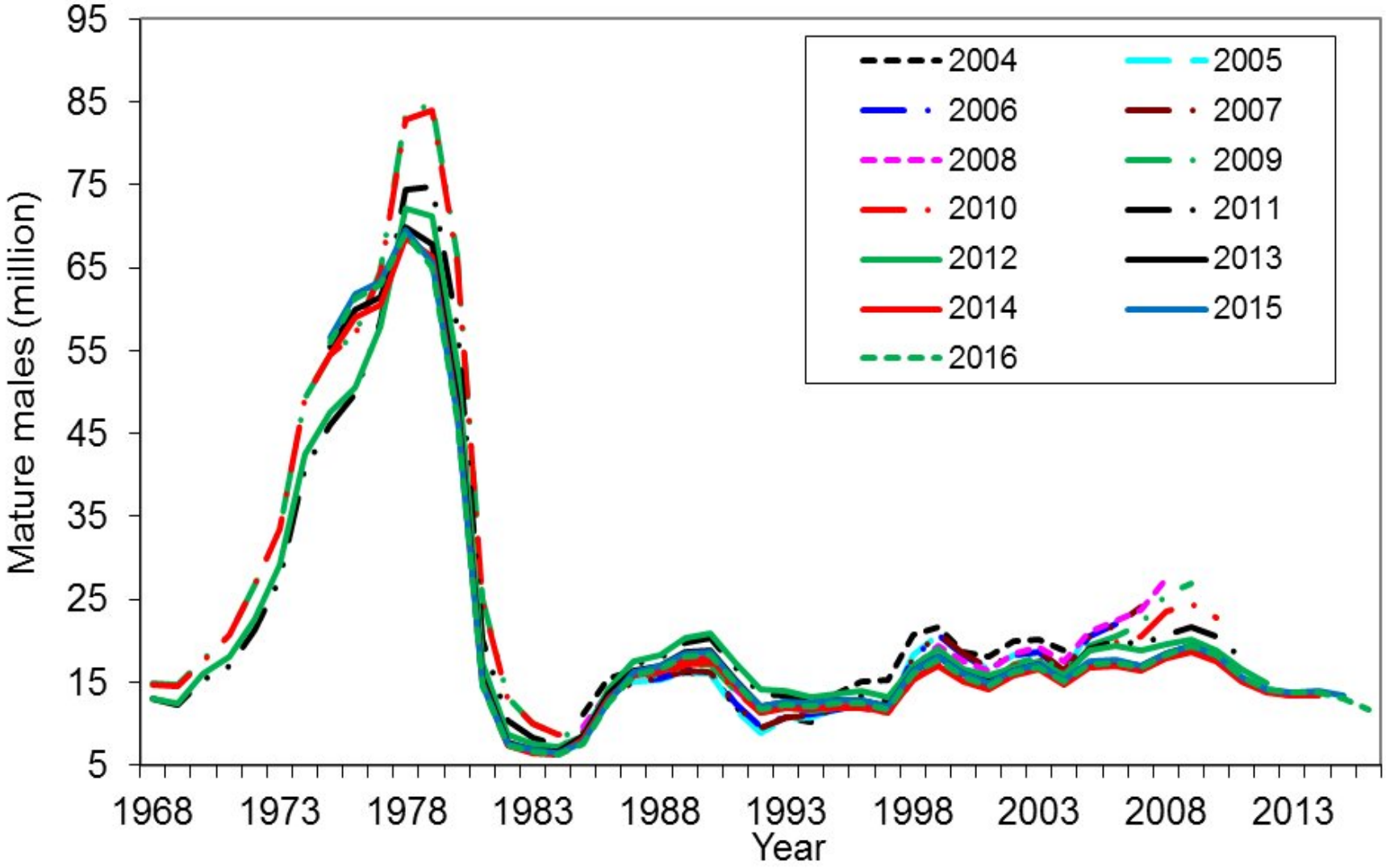


Scenario 1n
Females

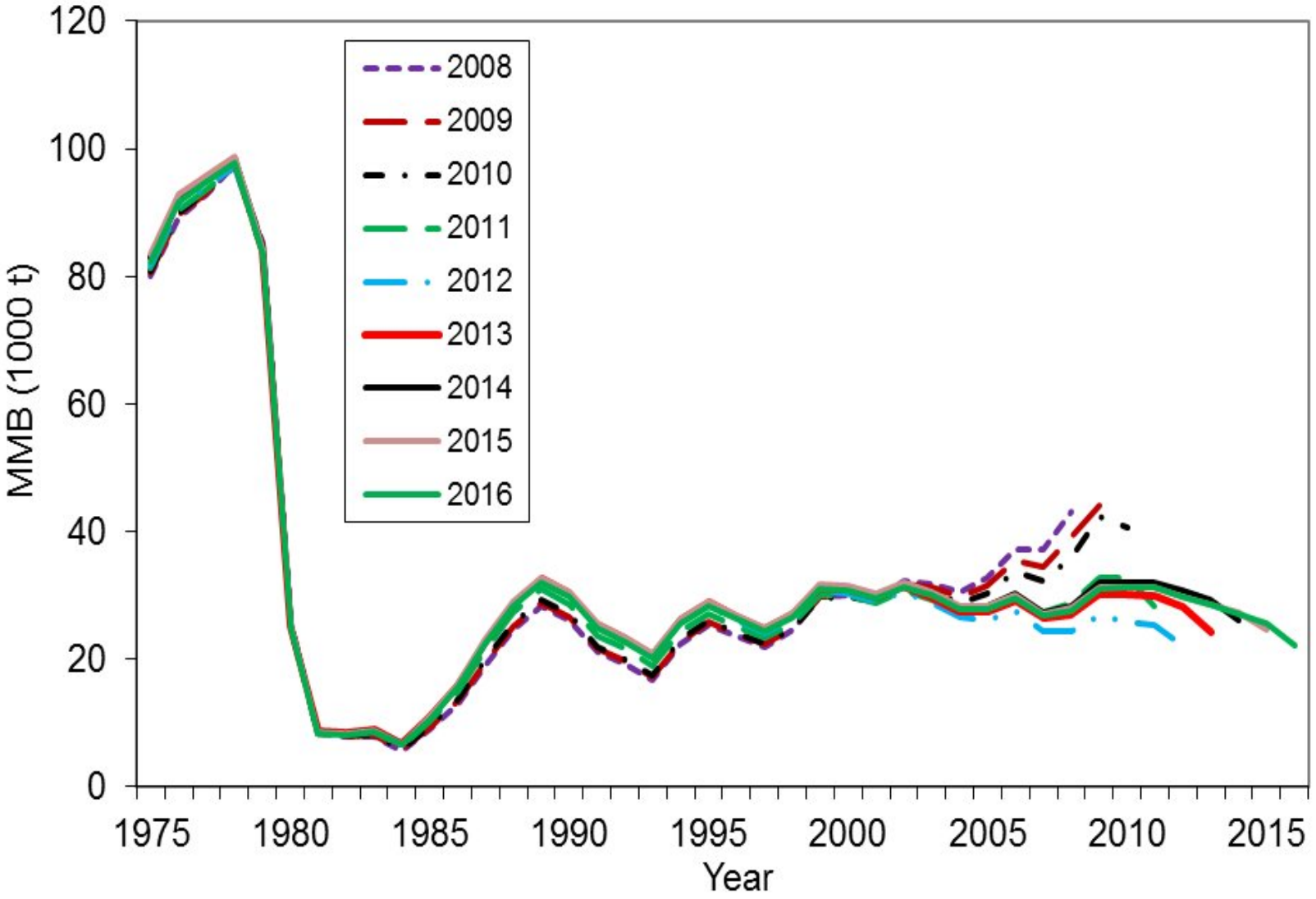
Scenario 1, historical results



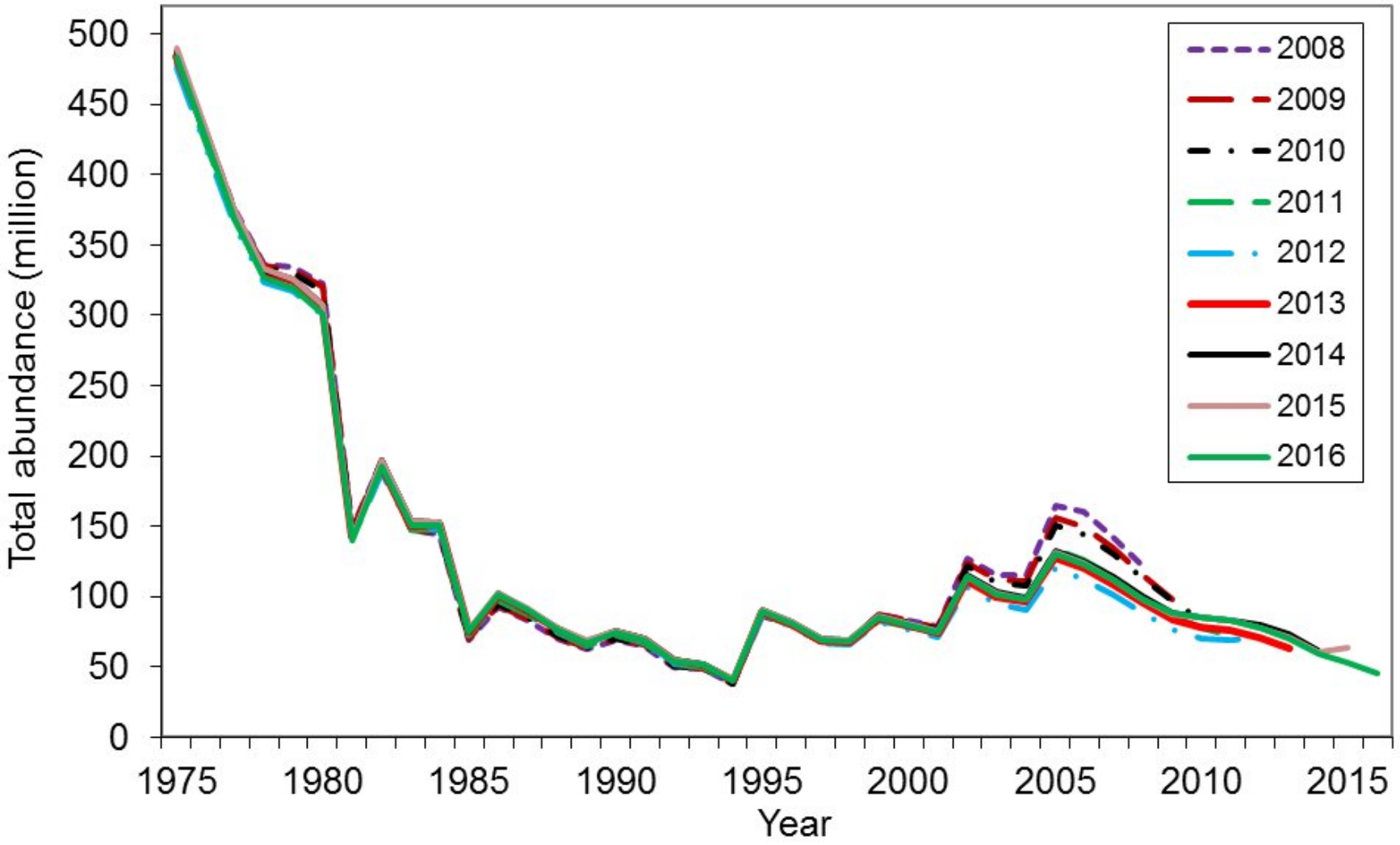
Scenario 1, historical results



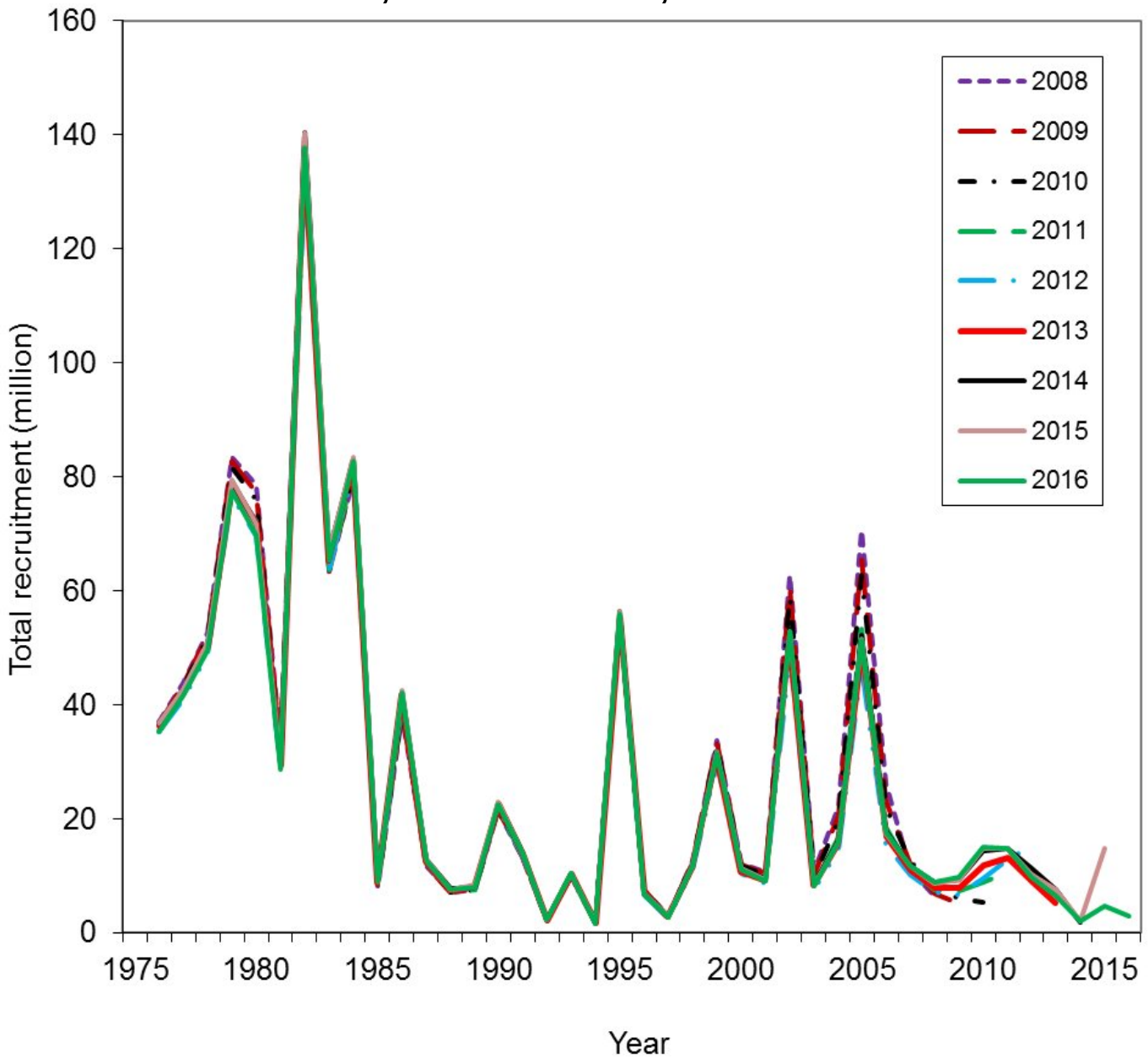
Scenario 1, 2016 model results

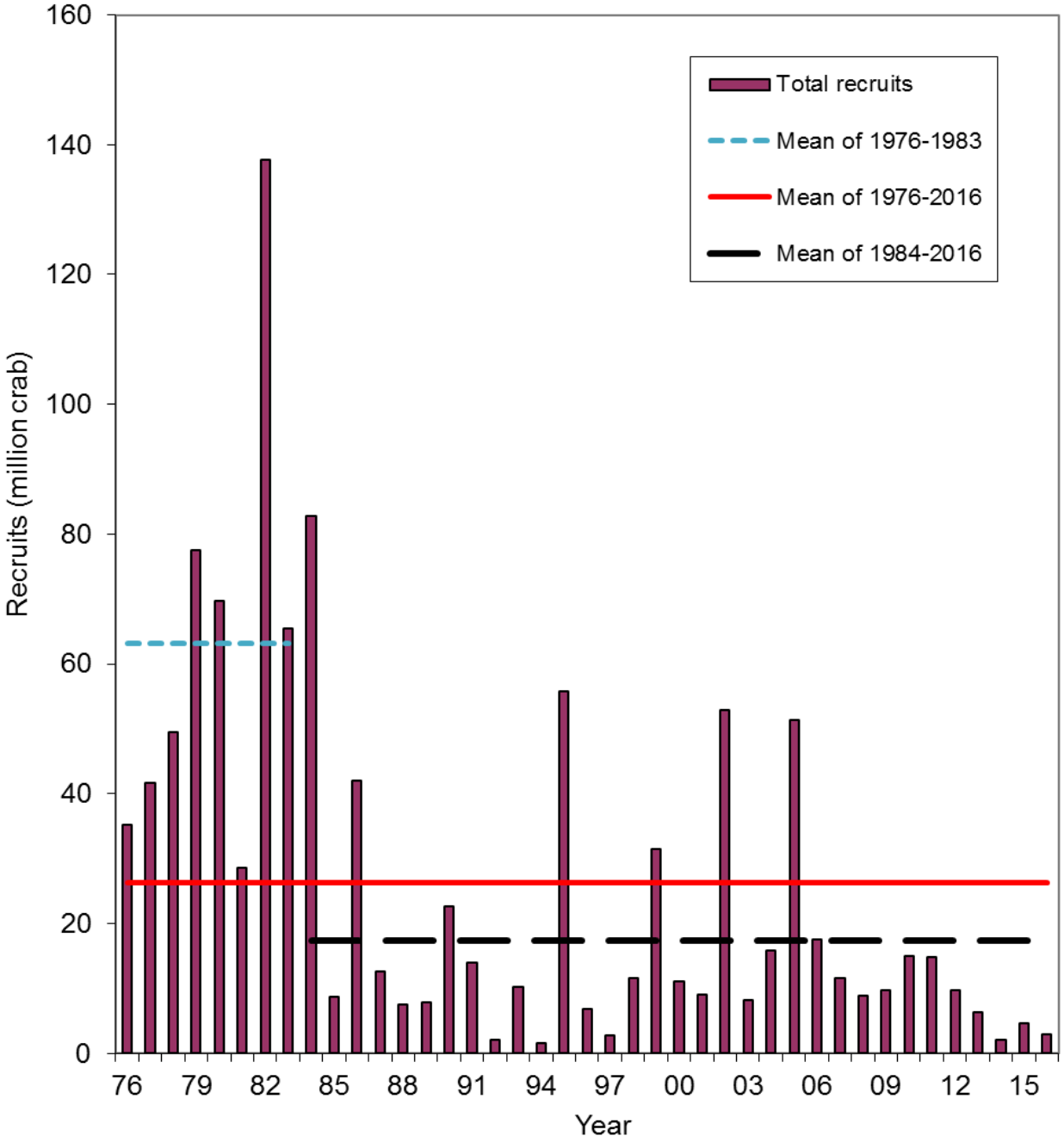


Scenario 1, 2016 model results

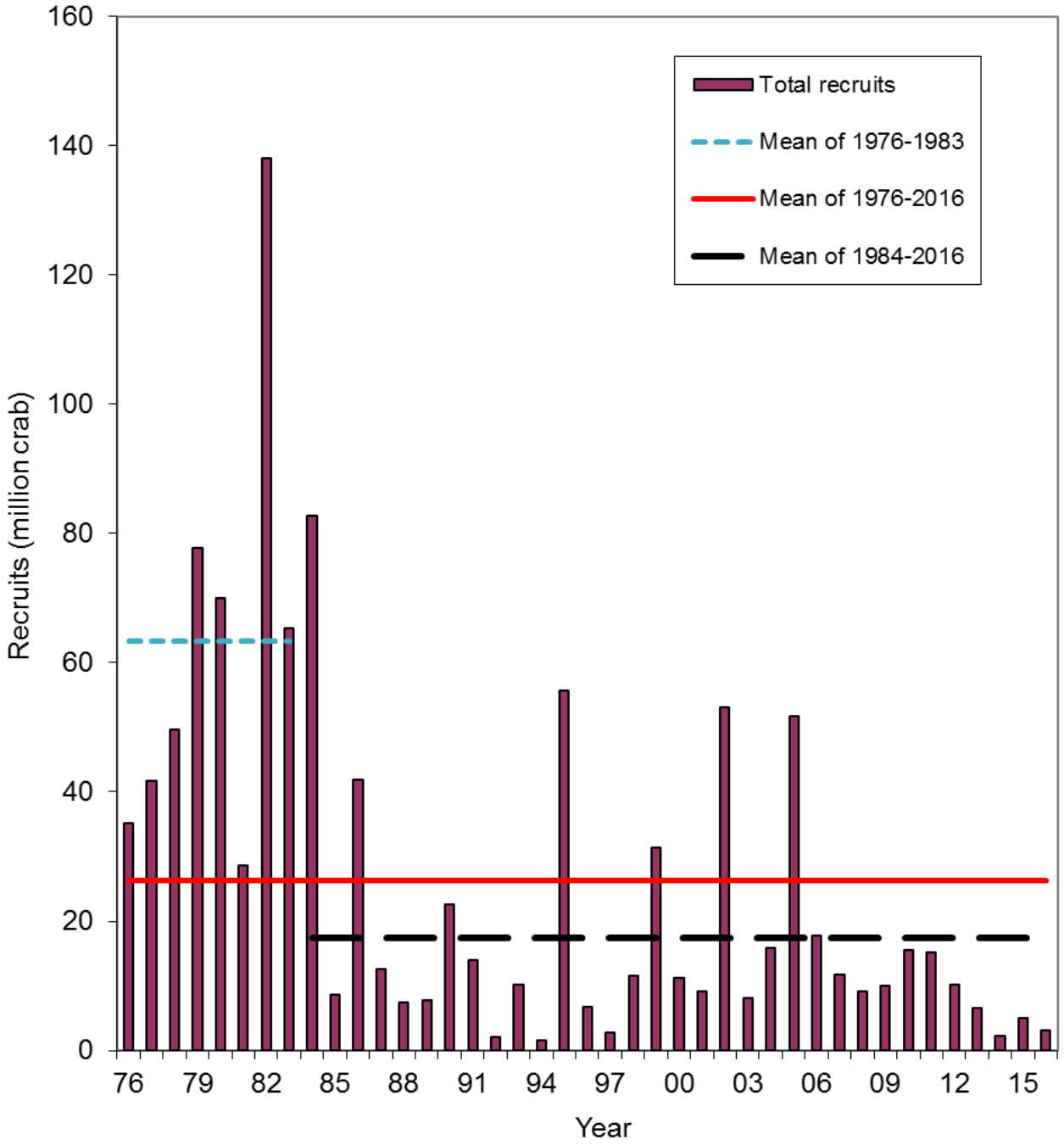


Total recruitment, scenario 1, 2016 model results

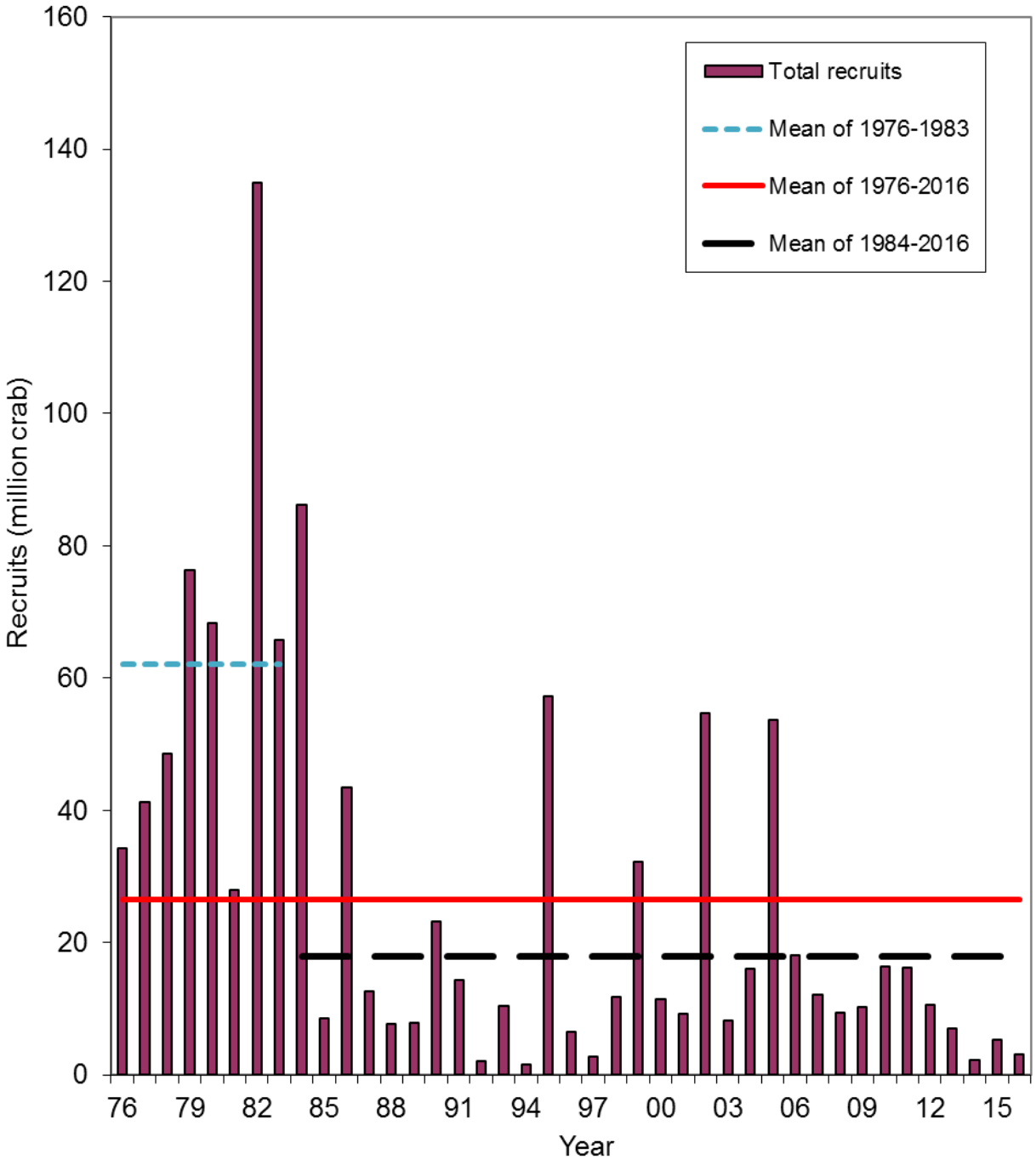



Total recruits
Mean of 1976-1983
Mean of 1976-2016
Mean of 1984-2016
Recruits (million crab)
160
140
120
100
80
60
40
20
0
76
79
82
85
88
91
94
97
00
03
06
09
12
15
Year

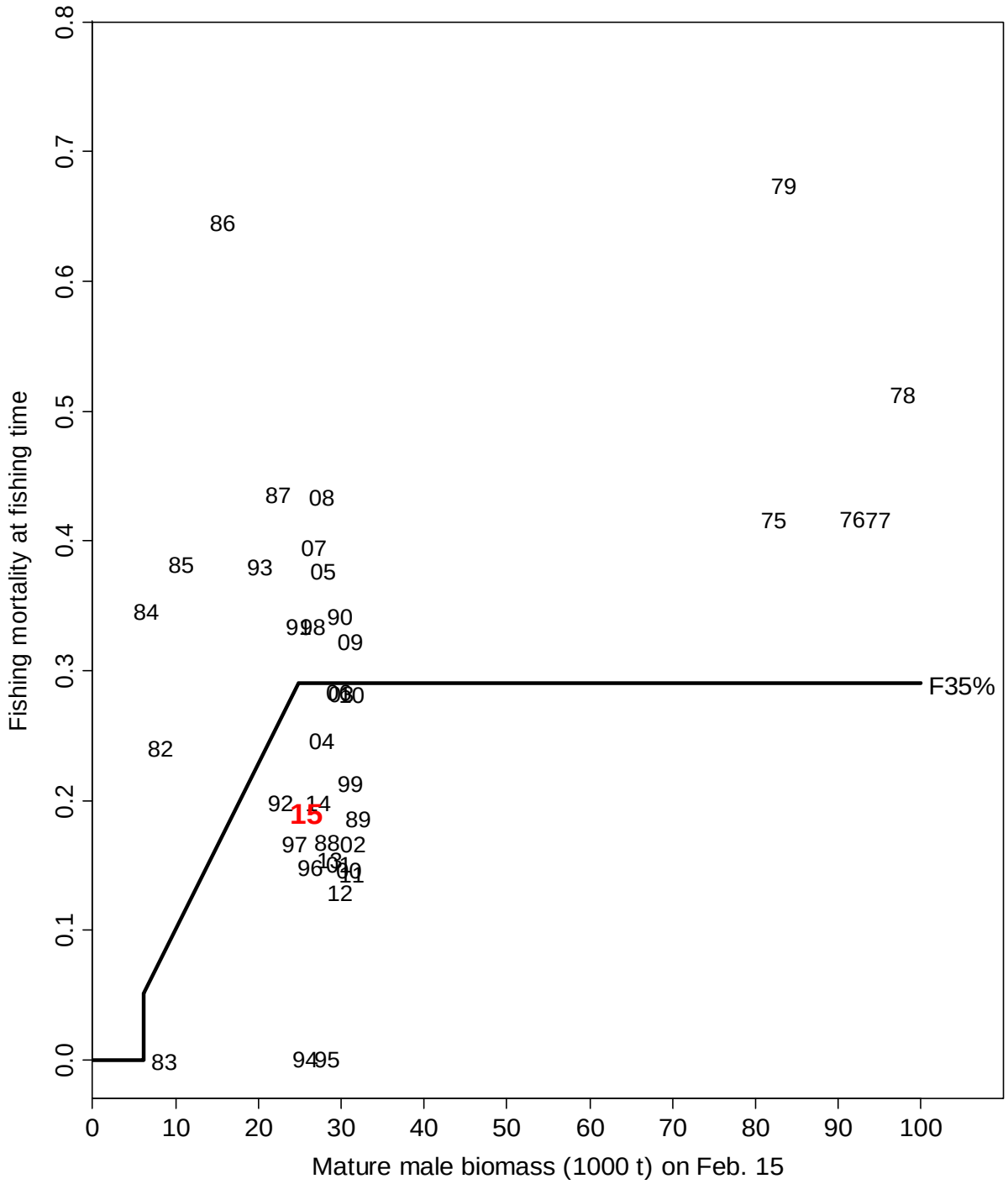
Scenario 1


Total recruits
Mean of 1976-1983
Mean of 1976-2016
Mean of 1984-2016
Recruits (million crab)
Year
0
20
40
60
80
100
120
140
160
76
79
82
85
88
91
94
97
00
03
06
09
12
15

Scenario 1n

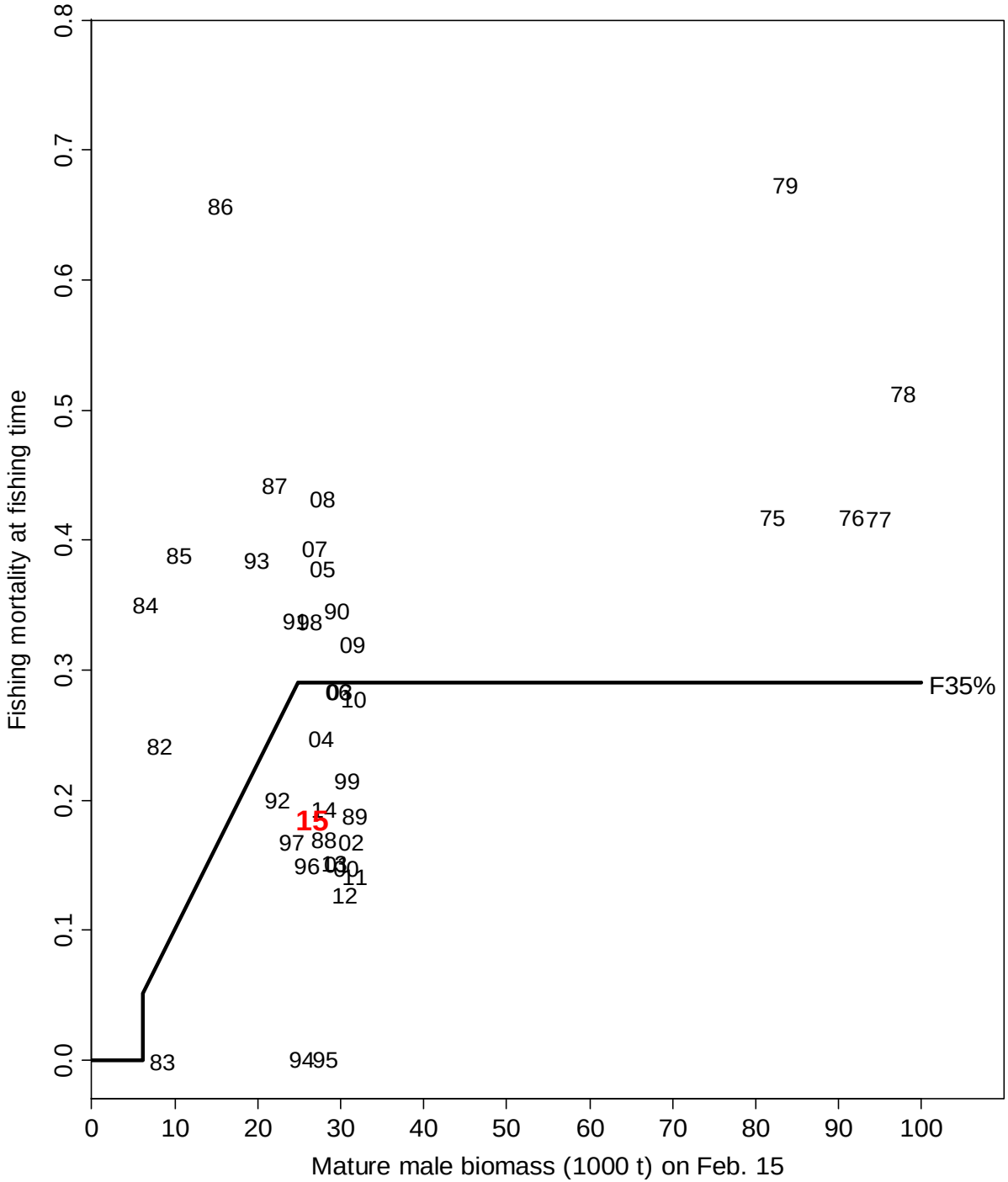

Total recruits
Mean of 1976-1983
Mean of 1976-2016
Mean of 1984-2016
Recruits (million crab)
160
140
120
100
80
60
40
20
0
76
79
82
85
88
91
94
97
00
03
06
09
12
15
Year

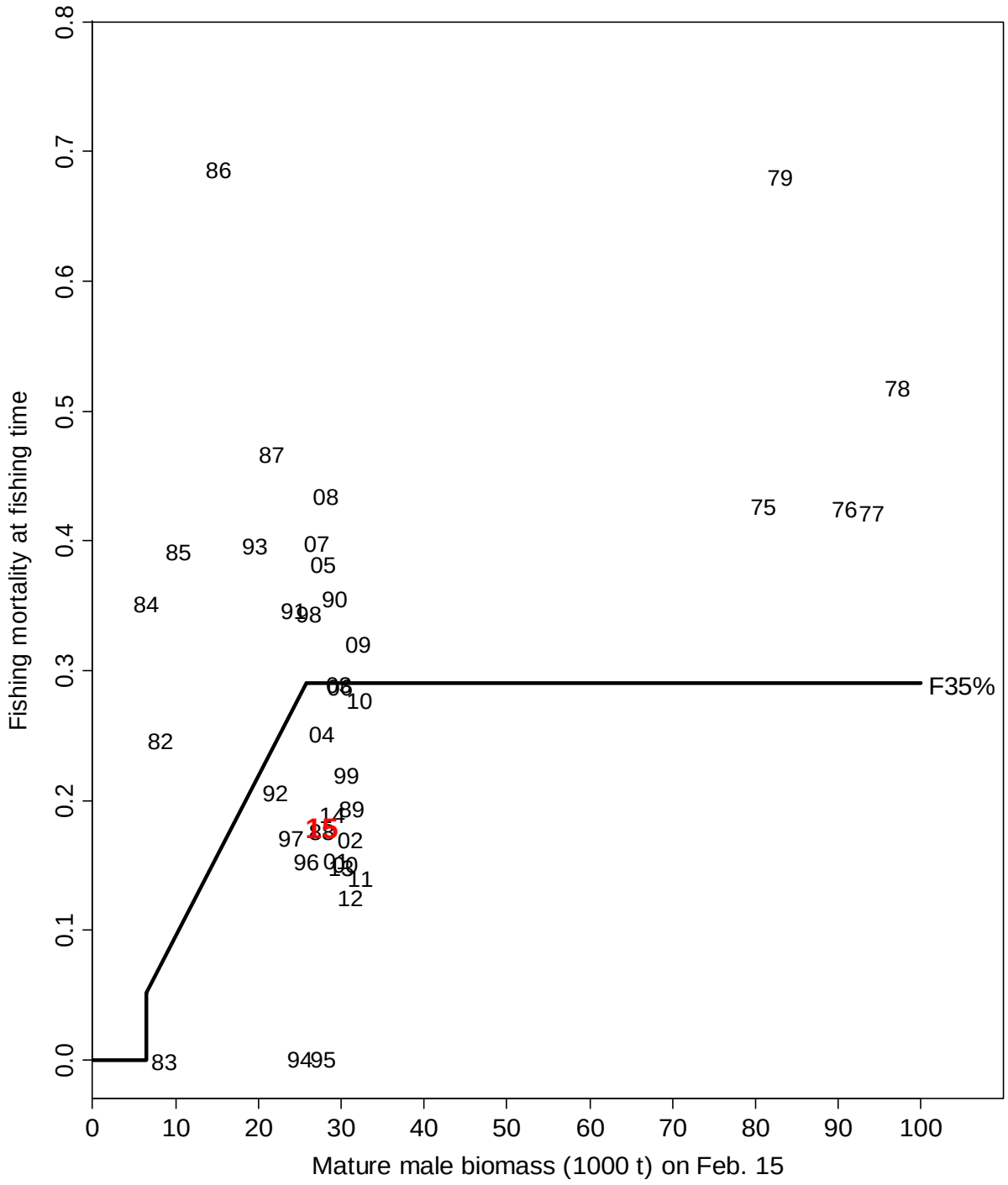
Scenario 2


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
79
86
78
87
08
75
76
77
07
85
93
05
84
90
09
04
82
99
92
14
15
89
97
88
02
96
12
83
94
95

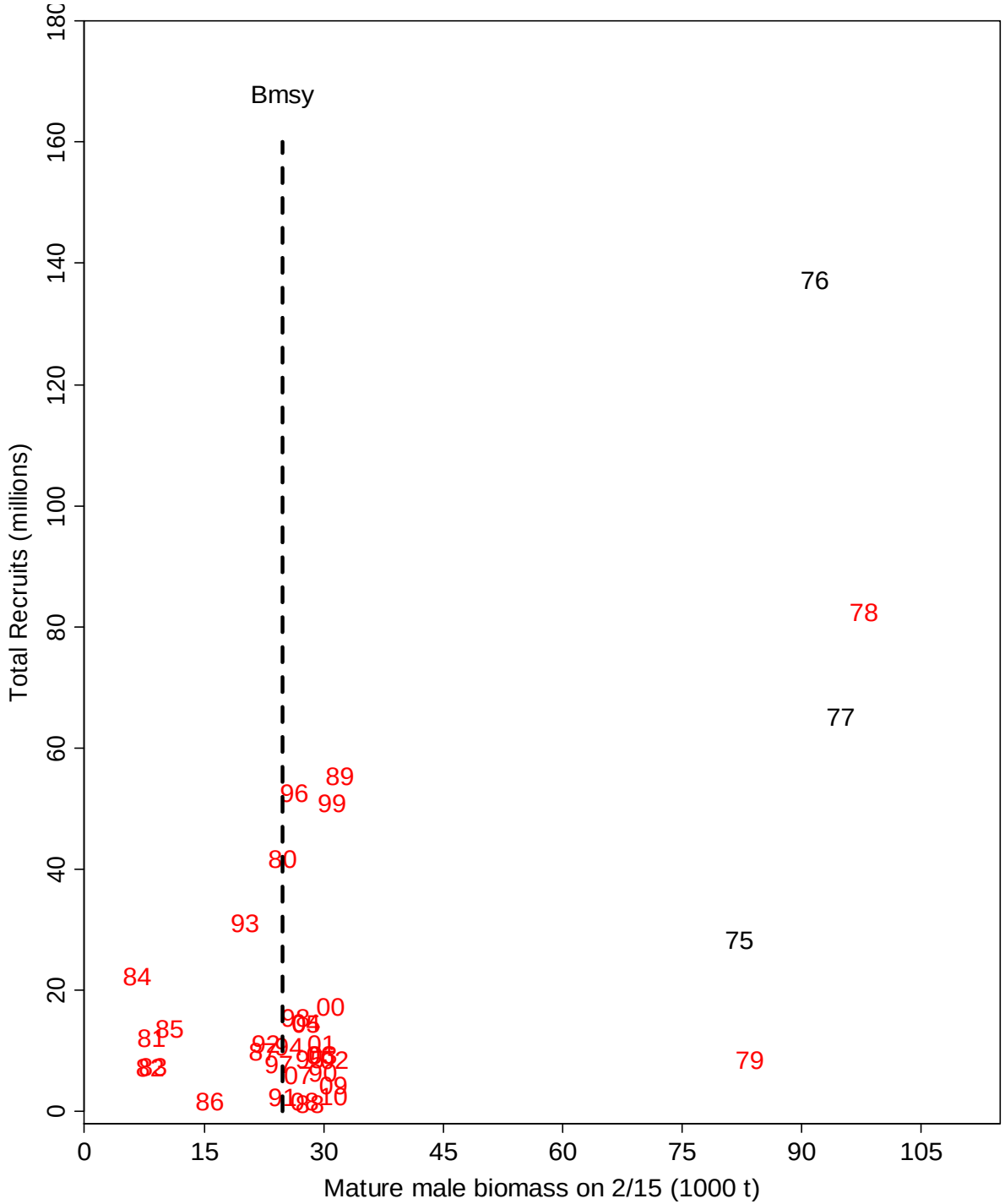
Scenario 1

Scenario 1n

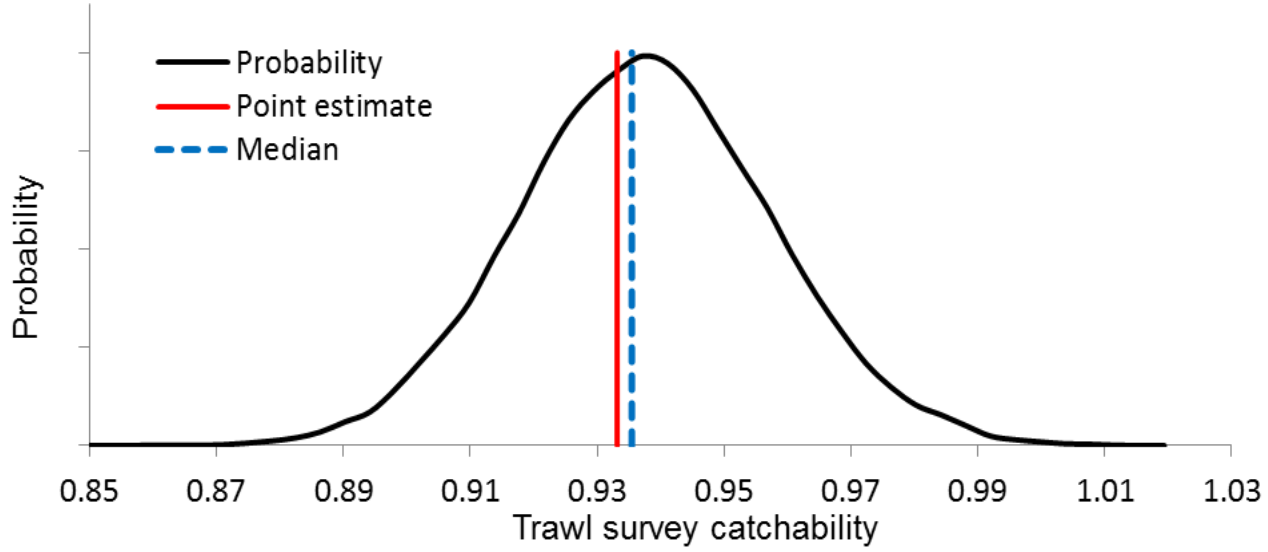

Fishing mortality at fishing time
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60
70
80
90
100
Mature male biomass (1000 t) on Feb. 15
F35%
79
86
78
87
08
75
76
77
85
93
07
05
84
90
09
10
04
82
99
92
14
89
15
97
88
02
11
12
83
94
95


Fishing mortality at fishing time
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
Mature male biomass (1000 t) on Feb. 15
F35%
86
79
78
87
08
75
76
77
85
93
07
05
84
91
98
90
09
10
82
04
99
92
89
97
02
96
11
12
83
94
95

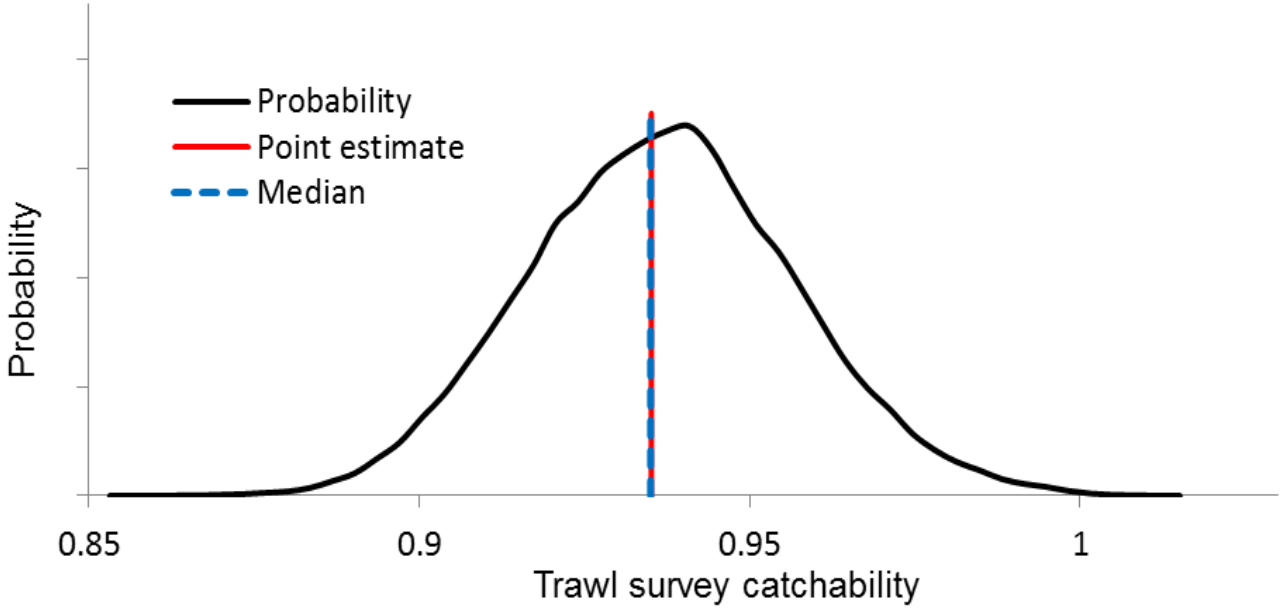
Scenario 2


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
00
85
81
79
86

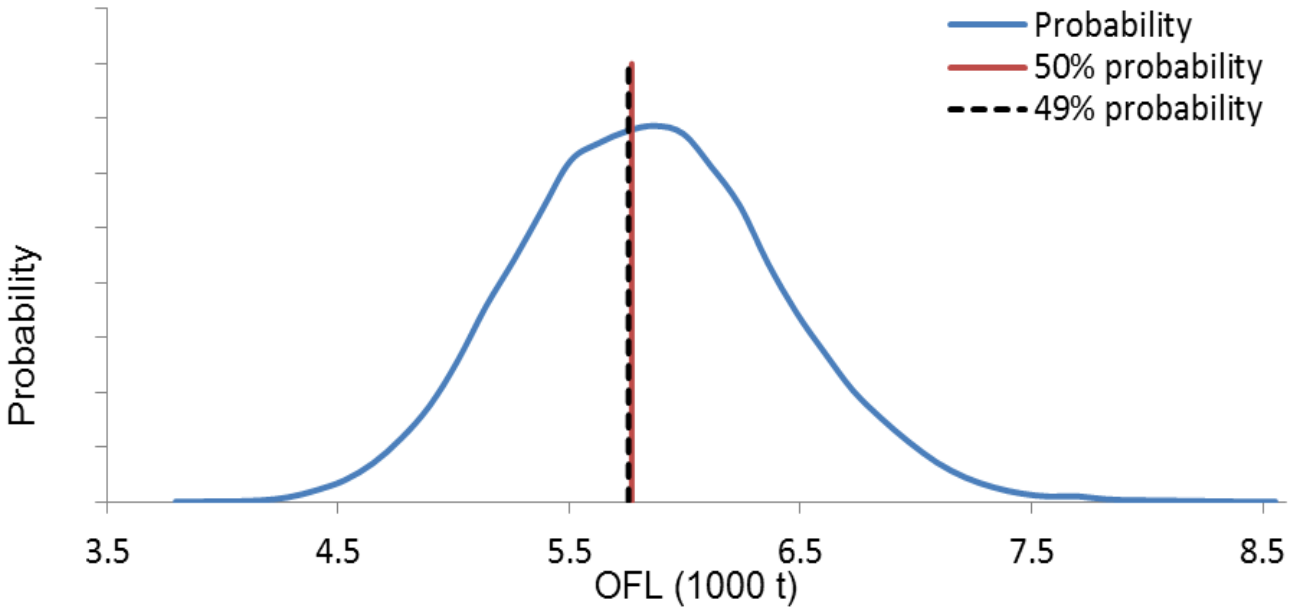
Scenario 1



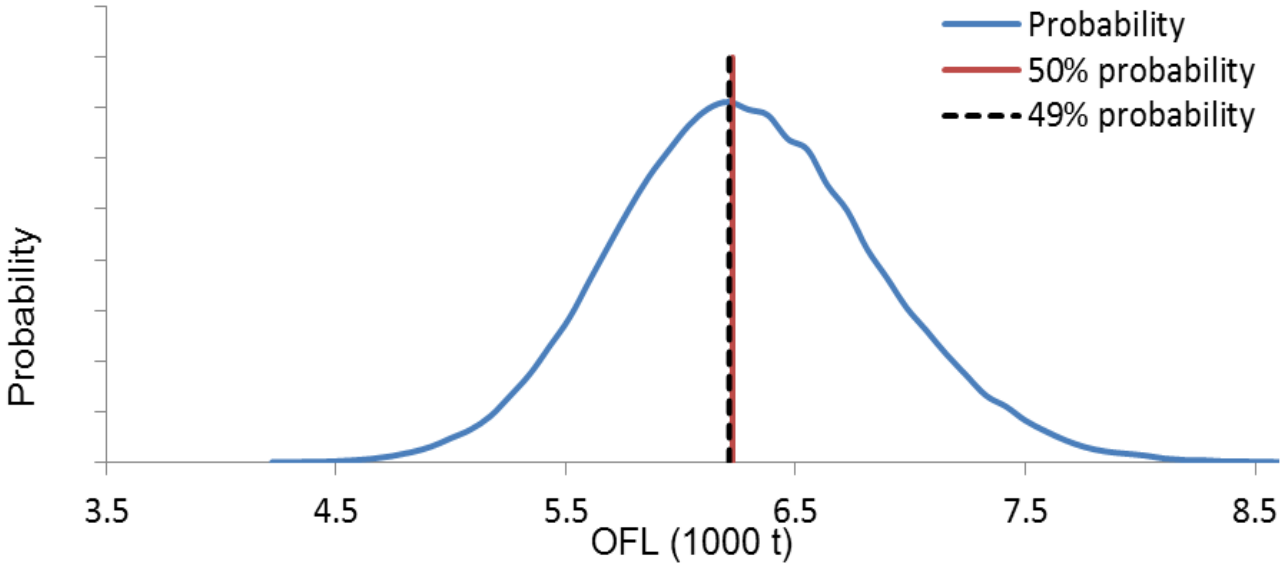
Scenario 1
2016



Scenario 1n
2016



Scenario 1
2016



Scenario 1n
2016

Based on the $B_{35\%}$ estimated from the average male recruitment during 1984-2016, the biological reference points and OFL:
(based on the 10% rule used last year, ABC = 0.9*OFL)

	Scenario 1		Scenario 1n		Scenario 2	
	1000t	Million lbs	1000t	Million lbs	1000t	Million lbs
$B_{35\%}$	24.777	54.624	24.907	54.910	25.785	56.846
$F_{35\%}$	0.29		0.29		0.29	
MMB_{2015}	22.381	49.341	23.014	50.736	23.999	52.908
OFL_{2015}	6.040	13.316	6.385	14.076	6.637	14.633
ABC_{2015}	5.436	11.984	5.746	12.668	5.937	13.169

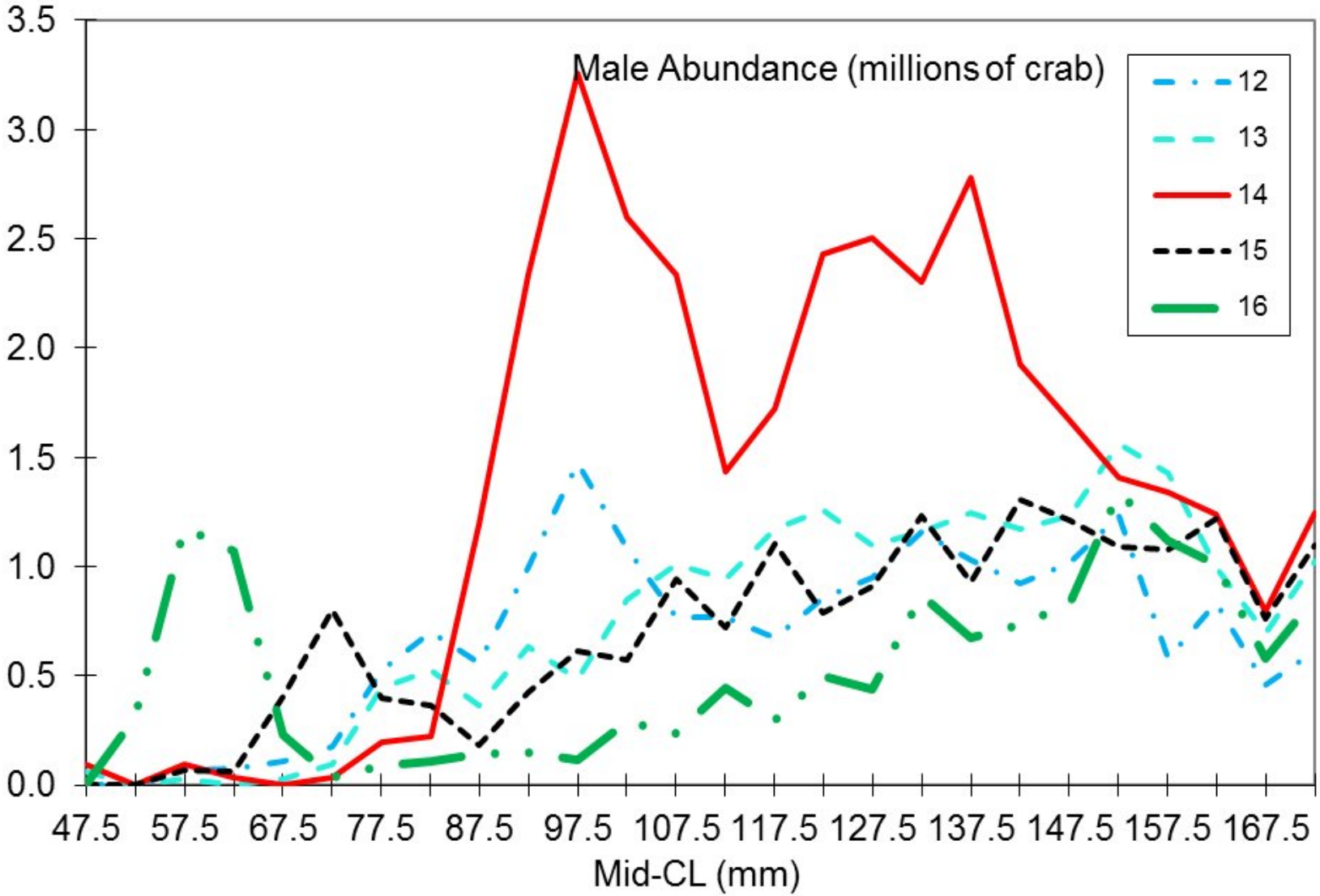
Status and catch specifications in 1000 t (scenario 1n):

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2012/13	13.19[A]	29.05[A]	3.56	3.62	3.90	7.96	7.17
2013/14	12.85[B]	27.12[B]	3.90	3.99	4.56	7.07	6.36
2014/15	13.03[C]	27.25[C]	4.49	4.54	5.44	6.82	6.14
2015/16	12.45[D]	26.59[D]	4.52	4.61	5.34	6.73	6.06
2016/17		23.01[D]				6.38	5.75

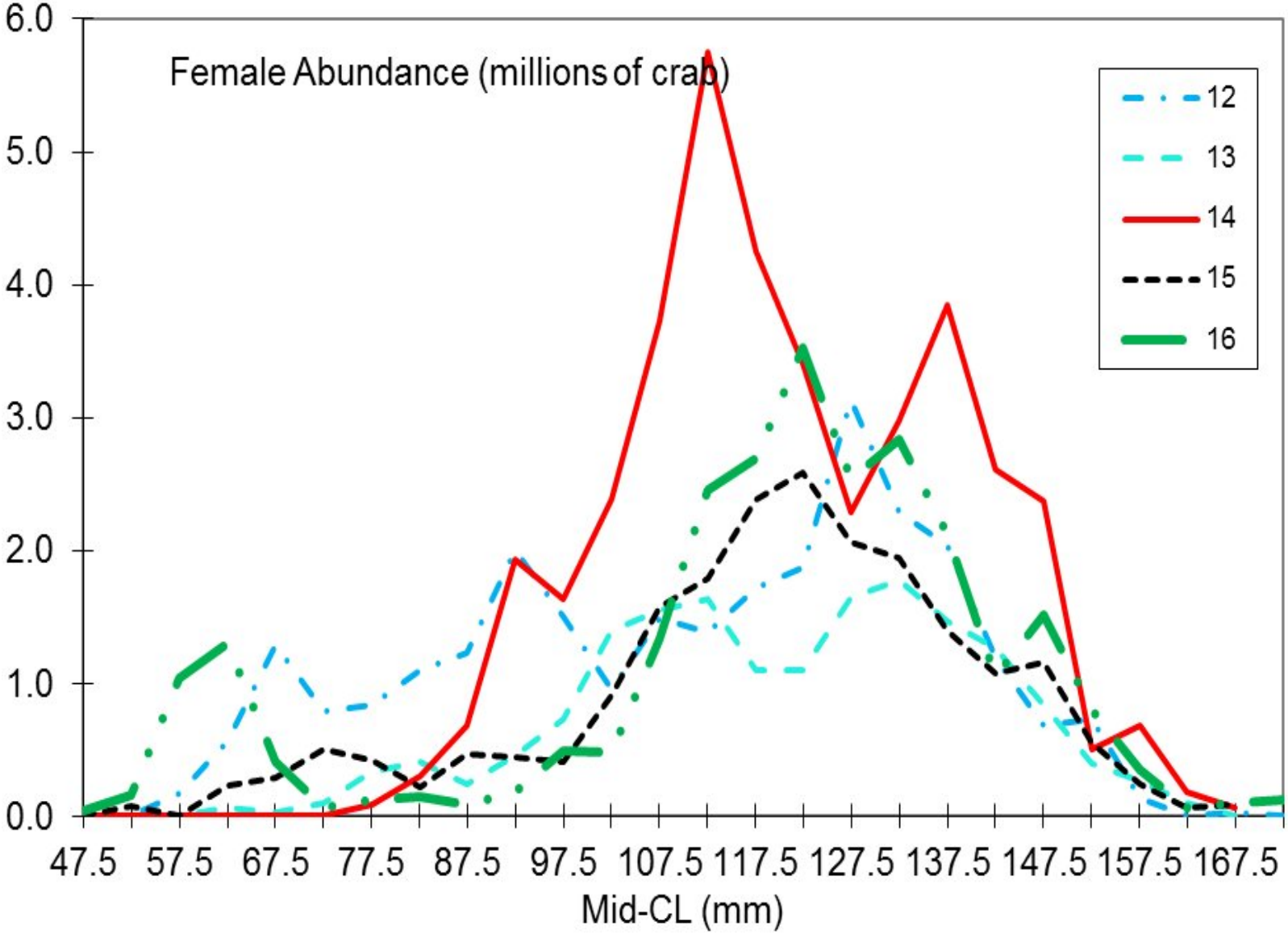
Basis for the OFL: All table values are in 1000 t (scenario 1n):

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
2012/13	3b	27.5	26.3	0.96	0.31	1984-2012	0.18
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	24.9	23.0	0.92	0.27	1984-2016	0.18

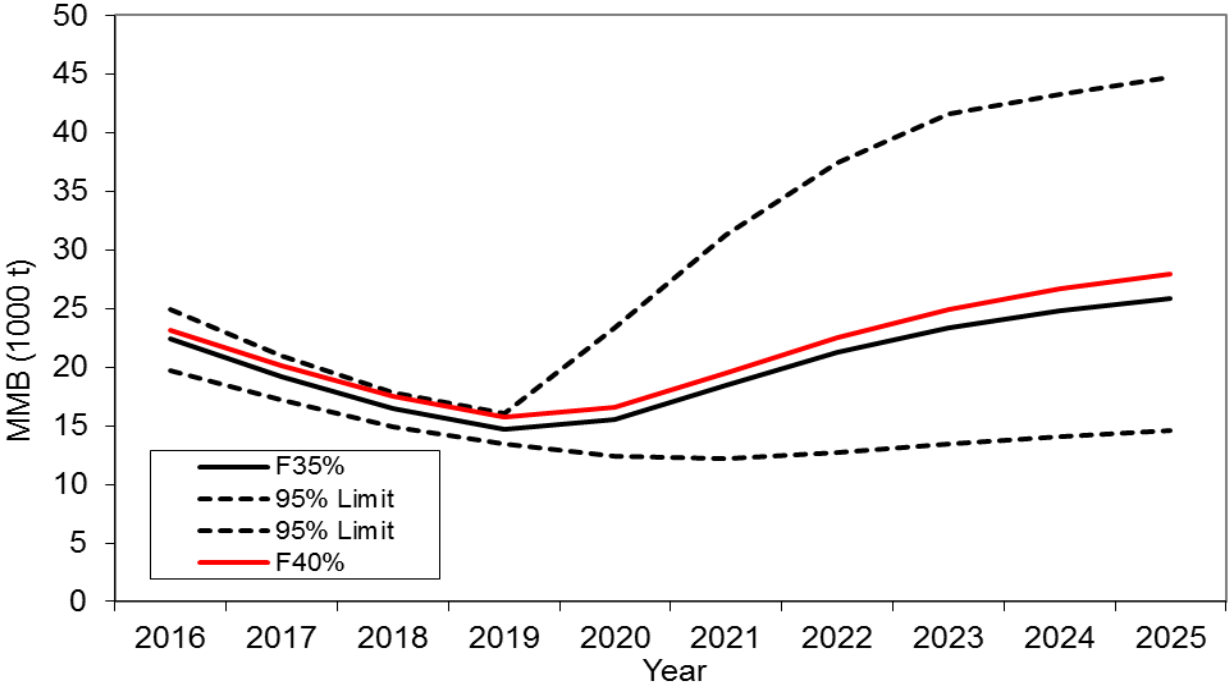
Male area-swept abundance during 2012-2016

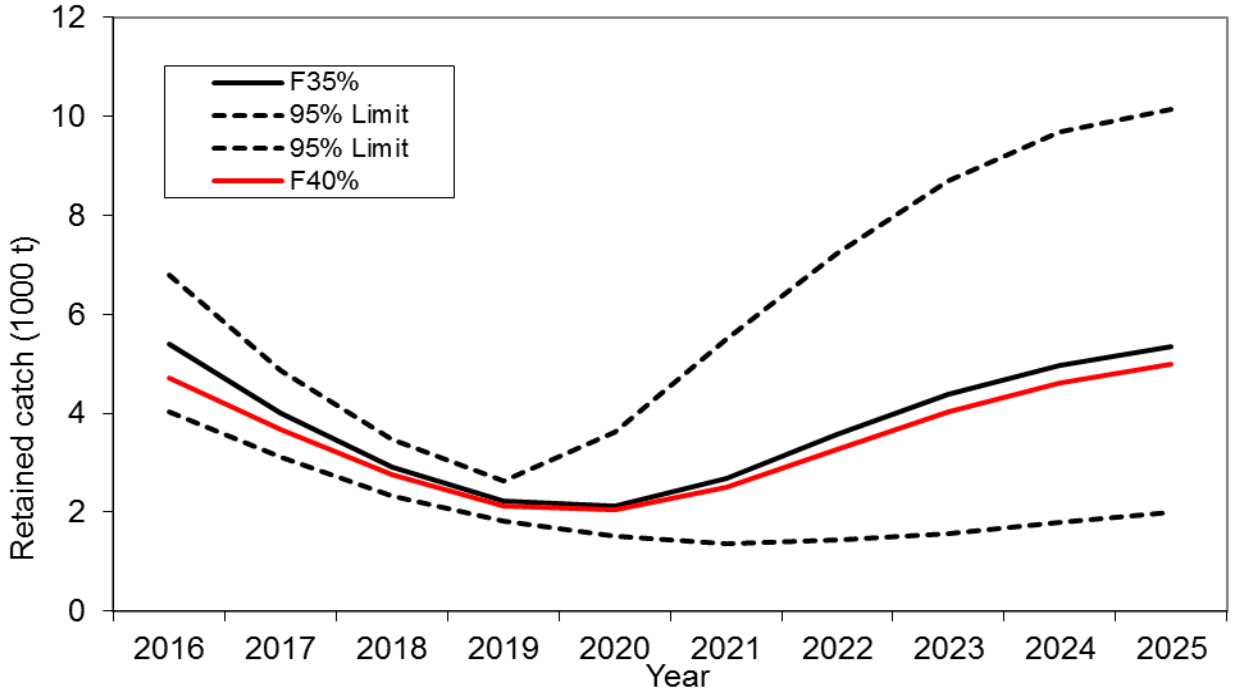


Female area-swept abundance during 2012-2016

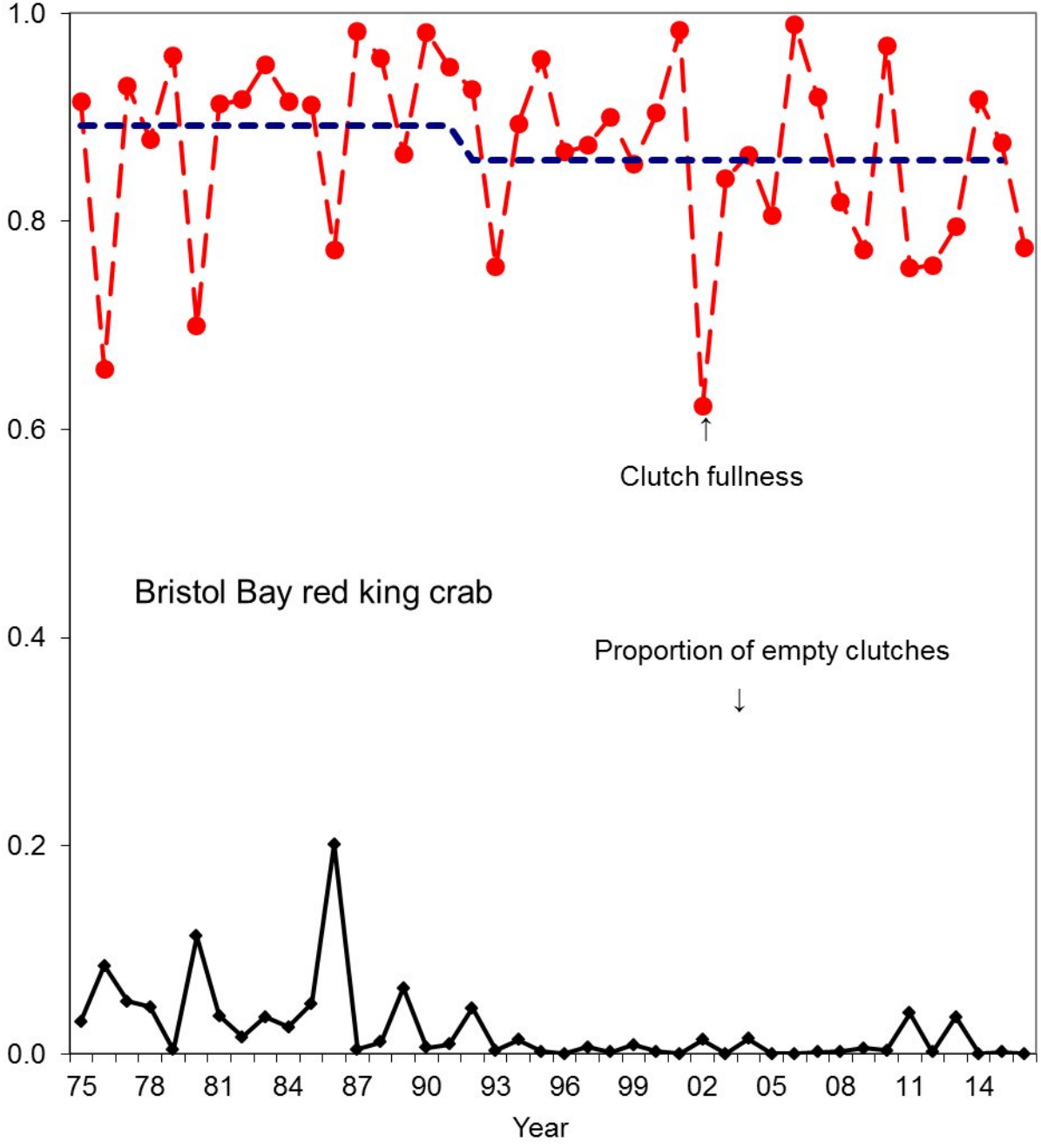


Scenario 1


MMB (1000 t)
50
45
40
35
30
25
20
15
10
5
0
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year
F35%
95% Limit
95% Limit
F40%


Retained catch (1000 t)
12
10
8
6
4
2
0
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year
F35%
95% Limit
95% Limit
F40%

Thanks



Clutch fullness fluctuated over time.