St. Matthew Island Blue King Crab Assessment in Fall 2015

J. Zheng and D. Pengilly

ADF&G, Juneau & Kodiak

R-24

How to deal with this “Odd” guy?

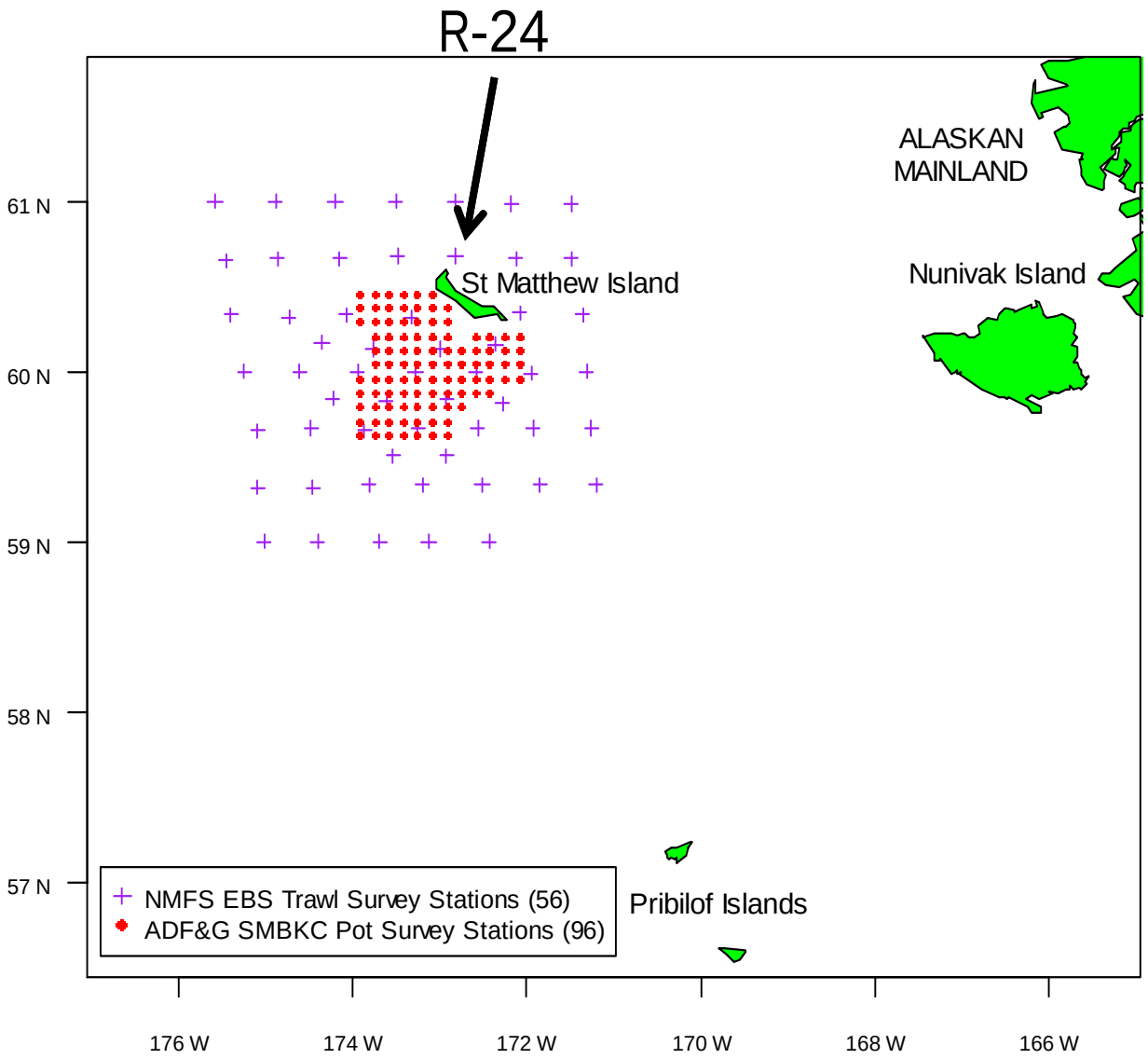
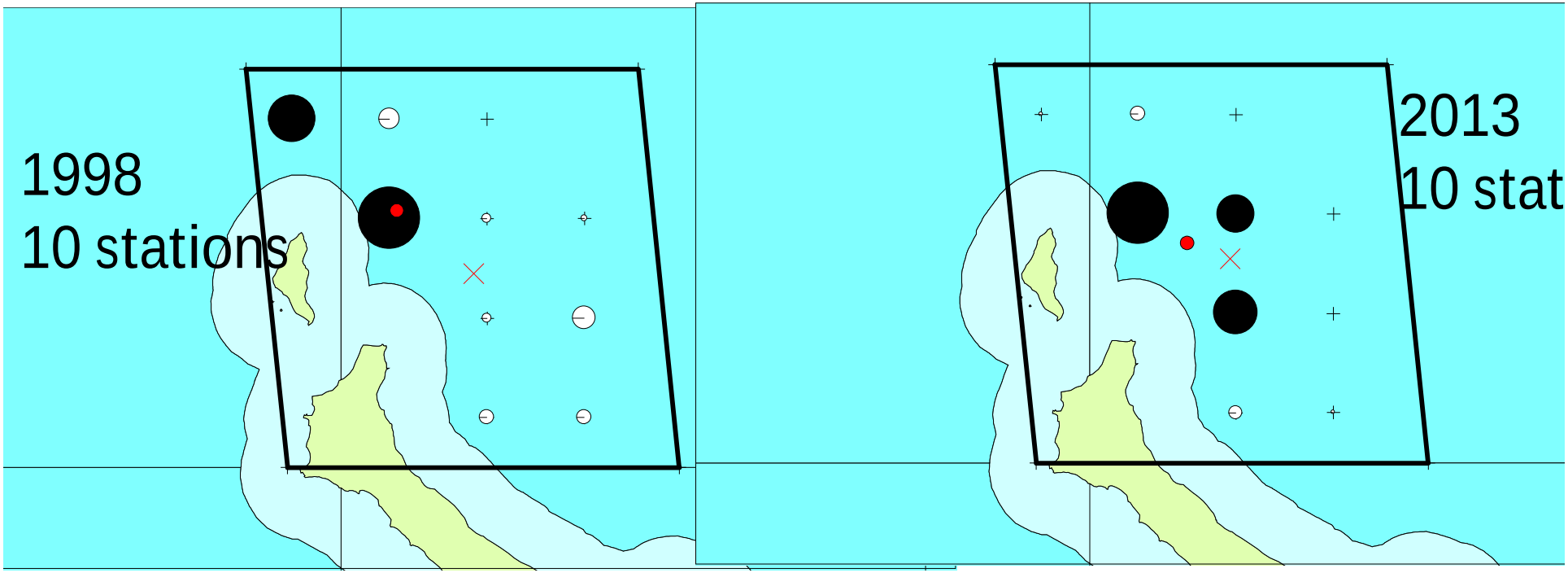

R-24
ALASKAN
MAINLAND
Nunivak Island
St Matthew Island
Pribilof Islands
61 N
60 N
59 N
58 N
57 N
176 W
174 W
172 W
170 W
168 W
166 W
NMFS EBS Trawl Survey Stations (56)
ADF&G SMBKC Pot Survey Stations (96)

Table 6. Density (number of crab per sq-nm) of male blue king crab ≥ 90 mm CL in trawl station R-24 relative to the single-tow and multi-tow strata averages.

	R-24	SM single-tow stratum (without R-24)				SM multi-tow stratum			
Year	Density	N tows	Average density	Sample Std Dev	(R-24 - Avg)/(St. D.)	N tows	Average density	Sample Std Dev	(R-24 - Avg)/(St. D.)
1978	2,531.8	38	299.7	855.5	2.61	0	-	-	-
1979	202.6	36	489.6	1,402.0	-0.20	0	-	-	-
1980	883.4	37	512.6	1,864.9	0.20	0	-	-	-
1981	64.3	36	265.3	589.1	-0.34	0	-	-	-
1982	73.7	39	636.5	1,598.2	-0.35	0	-	-	-
1983	0.0	26	60.8	220.4	-0.28	27	751.3	1,411.0	-0.53
1984	85.3	26	49.8	111.3	0.32	27	253.6	251.4	-0.67
1985	-	26	11.1	33.5	-	27	243.3	286.7	-
1986	0.0	26	17.9	77.7	-0.23	27	116.2	294.6	-0.39
1987	219.4	28	8.4	32.6	6.47	23	206.2	327.1	0.04
1988	294.9	28	9.4	36.3	7.87	26	271.4	428.2	0.05
1989	79.8	28	13.2	69.6	0.96	27	682.9	1,148.9	-0.52
1990	507.7	28	24.2	128.1	3.78	24	546.8	878.9	-0.04
1991	778.7	28	77.1	148.1	4.74	25	535.9	855.0	0.28
1992	1,510.8	28	52.7	145.0	10.05	27	491.6	519.6	1.96
1993	1,312.8	28	20.7	73.4	17.61	27	812.8	789.8	0.63
1994	950.2	28	22.4	74.4	12.48	26	527.1	511.6	0.83
1995	886.8	28	88.4	202.0	3.95	27	361.0	368.4	1.43
1996	2,753.0	28	16.4	48.8	56.05	26	679.5	845.1	2.45
1997	6,218.4	28	37.6	124.2	49.75	27	591.0	612.6	9.19
1998	3,971.3	28	24.2	82.7	47.73	27	457.9	782.8	4.49
1999	69.2	28	10.3	32.7	1.80	26	119.1	126.1	-0.40
2000	296.3	28	5.7	29.9	9.71	27	155.8	268.2	0.52
2001	316.8	28	0.0	0.0	-	27	239.9	312.7	0.25
2002	182.0	28	7.1	20.9	8.36	27	114.7	211.2	0.32
2003	0.0	28	0.0	0.0	-	27	165.4	343.0	-0.48
2004	0.0	28	4.7	25.1	-0.19	27	130.2	260.7	-0.50
2005	691.8	28	29.7	145.3	4.56	26	72.0	144.7	4.28
2006	218.3	28	15.2	56.6	3.59	27	351.9	675.8	-0.20
2007	5,821.9	28	22.4	54.2	106.93	27	435.6	440.6	12.23
2008	788.3	28	9.5	23.7	32.87	27	441.4	716.2	0.48
2009	2,929.6	28	53.0	139.8	20.58	27	467.4	465.6	5.29
2010	12,920.7	28	57.5	118.6	108.47	27	529.4	687.4	18.03
2011	12,041.2	28	62.3	204.5	58.57	27	378.8	379.9	30.70
2012	3,894.9	28	57.3	125.5	30.57	27	315.7	303.8	11.78
2013	487.1	28	24.5	54.1	8.56	27	155.6	190.5	1.74
2014	4,958.0	28	0.0	0.0	-	27	300.8	468.6	9.94
2015	8,140.7	28	2.3	12.3	661.43	27	131.6	241.2	33.20



ADF&G Pot surveys in station R-24

Red circle: The centroid of distribution
Red X: mid-point of the NMFS trawl
Black circle: catch > the average catch
White circle: Catch < the average catch

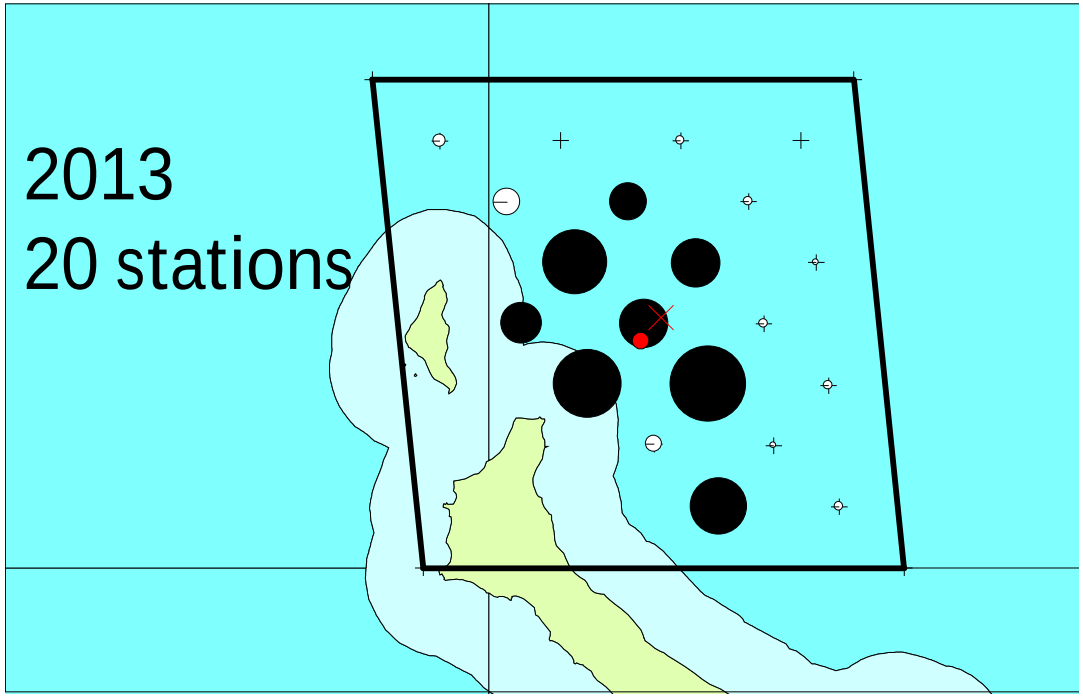
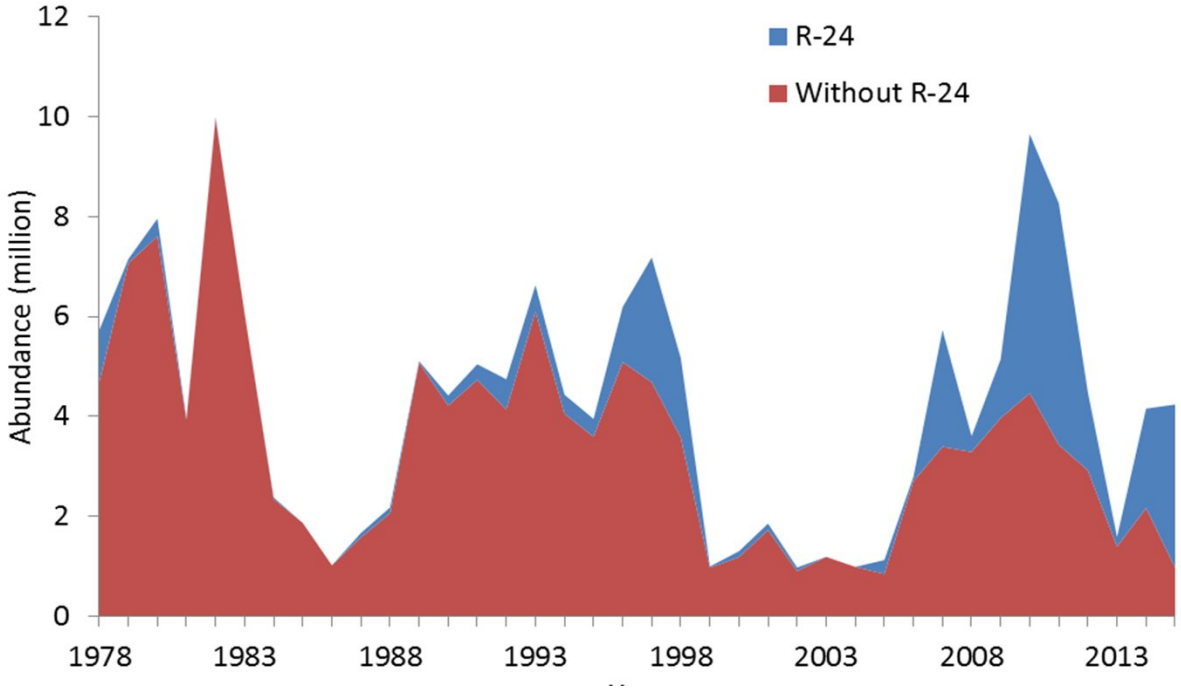


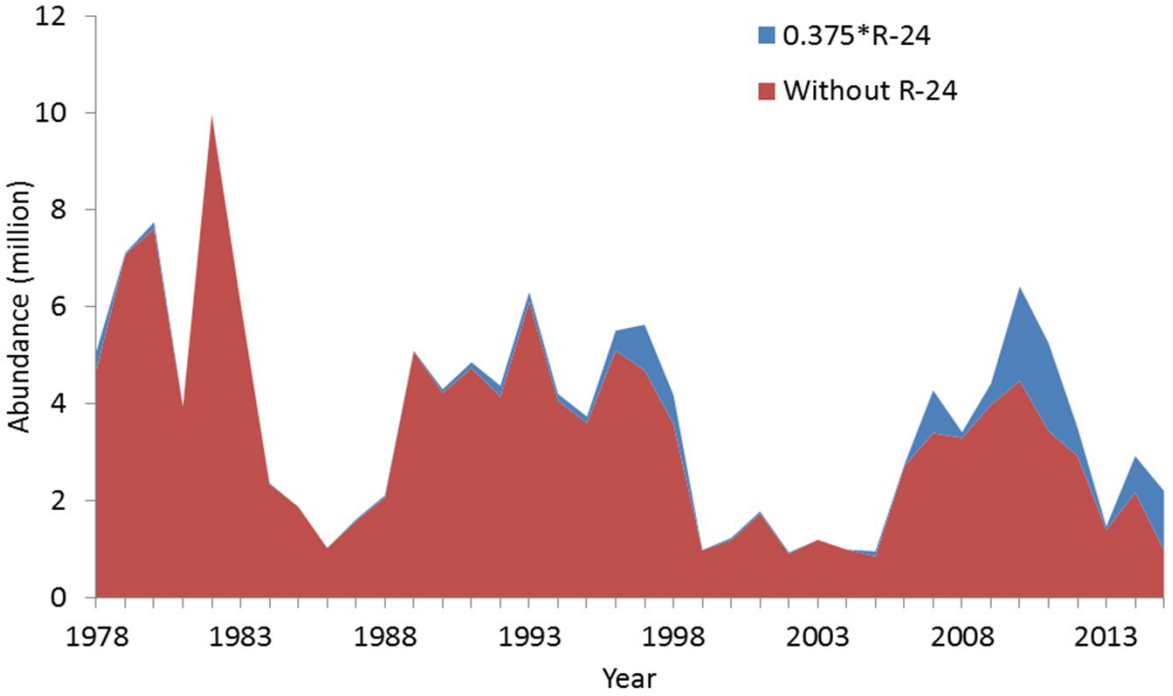
Table 7. Pot survey station rank within trawl survey station R-24, male catch (>89 mm CL) in each station, and cumulative percentage of catch in 1998, 2013 and 2015. Two pot surveys were conducted in 2013, one with 10 stations and another with 20 stations. The highlighted is top 40% of total pot stations.

Station	1998		2013		2013		2015	
rank	Catch	Cumu.%	Catch	Cumu.%	Catch	Cumu.%	Catch	Cumu.%
1	43	43.88%	76	45.51%	63	18.86%	105	35.12%
2	27	71.43%	43	71.26%	53	34.73%	66	57.19%
3	8	79.59%	33	91.02%	48	49.10%	25	65.55%
4	7	86.73%	7	95.21%	38	60.48%	17	71.24%
5	4	90.82%	6	98.80%	30	69.46%	12	75.25%
6	4	94.90%	1	99.40%	30	78.44%	10	78.60%
7	2	96.94%	1	100.00%	22	85.03%	10	81.94%
8	2	98.98%	0	100.00%	19	90.72%	8	84.62%
9	1	100.00%	0	100.00%	11	94.01%	7	86.96%
10	0	100.00%	0	100.00%	5	95.51%	7	89.30%
11					3	96.41%	6	91.30%
12					2	97.01%	5	92.98%
13					2	97.60%	4	94.31%
14					2	98.20%	3	95.32%
15					2	98.80%	3	96.32%
16					2	99.40%	3	97.32%
17					1	99.70%	3	98.33%
18					1	100.00%	2	99.00%
19					0	100.00%	2	99.67%
20					0	100.00%	1	100.00%
Total	98		167		334		299	
Mean	9.8		16.7		16.7		14.95	



NMFS Trawl Area-Swept Estimates

Scenarios T, 0, 00, 1 to 11



NMFS Trawl Area-Swept Estimates

Scenarios 10-4, 9-4

Response to CPT Comments

"(1) Drop all current models from further consideration, (2) develop new model scenarios incorporating the following elements: (i) data weighting, (ii) additional variance, (iii) revised survey time series, (iv) selectivity (various time-blocks), and (v) molting probability (various time-blocks). The above elements should be added singly to model scenarios building from the base (2014 assessment model) to more easily discern the effects of the individual changes. In addition, the author should try to achieve parsimony in the final models."

Response: Twenty model scenarios were examined to address these comments.

Response to SSC Comments

1. No comments in June 2015.

Summary of Major Changes in 2015

1. Changes to the input data:
   a. Newly re-estimated trawl survey results provided by NMFS in 2015 were used.
   b. Catch and bycatch data were updated with 2015 data.
   c. Trawl bycatch biomass data during 2009-2014 were revised based on the new data provided by NMFS in 2015.
   d. Bottom temperature data collected during the NMFS summer trawl surveys were used to estimate trawl survey selectivities.

Summary of Major Changes in 2015

2. Changes to the assessment methodology:

Twenty scenarios:

T. Model T from September 2014.

0. Three modifications of scenario T:

(i) Effective sample sizes = min(N, 0.5*observed values) for surveys,
= min(N, 0.1*observed values) for observer data,
N = 100 for pot surveys, 50 for trawl surveys, and 50 observer data.

(ii) Converting weights to catch & bycatch biomass likelihood into CV.

(iii) Correcting mean weight for legal males (stage 3) (about 6 to 7% lower).

00. Scenario 0 plus reduction of penalty weights for groundfish fisheries bycatch fishing mortality. The weight changes from 1 to 0.01.

1. Scenario 00 plus changes in the effective sample sizes for pot fishery observer length composition data and use of pot fishery discarded biomass:
N = 25 during 1978-1998,
N = 50 during 2009-2014.

Summary of Major Changes in 2015

Twenty scenarios:

2. Scenario 1 plus estimating an additional CV for the pot survey CPUE.
3. Scenario 2 plus estimating constant molting probabilities over time.
4. Scenario 3 plus estimating trawl survey selectivities for two periods (before 2000 and 2000-present).
5. Scenario 3 plus estimating molting probabilities for two periods (before 2000 and 2000-present).
6. Scenario 4 plus estimating molting probabilities for two periods (before 2000 and 2000-present).
7. The same as scenario 4 except molting probabilities are 0.91 and 0.63 for respective stages 1 and 2 based on tagging data.
8. The same as scenario 5 except without estimating an additional CV for the pot survey CPUE and the molting probabilities during the period (1978-1999) are based on tagging data (0.91 and 0.63 for stages 1 and 2).

Summary of Major Changes in 2015

Twenty scenarios:

9. Scenario 7 plus estimating two pot survey selectivities for two periods (before 2000 and 2000-present).

10. The same as scenario 9 except without estimating an additional CV for the pot survey CPUE.

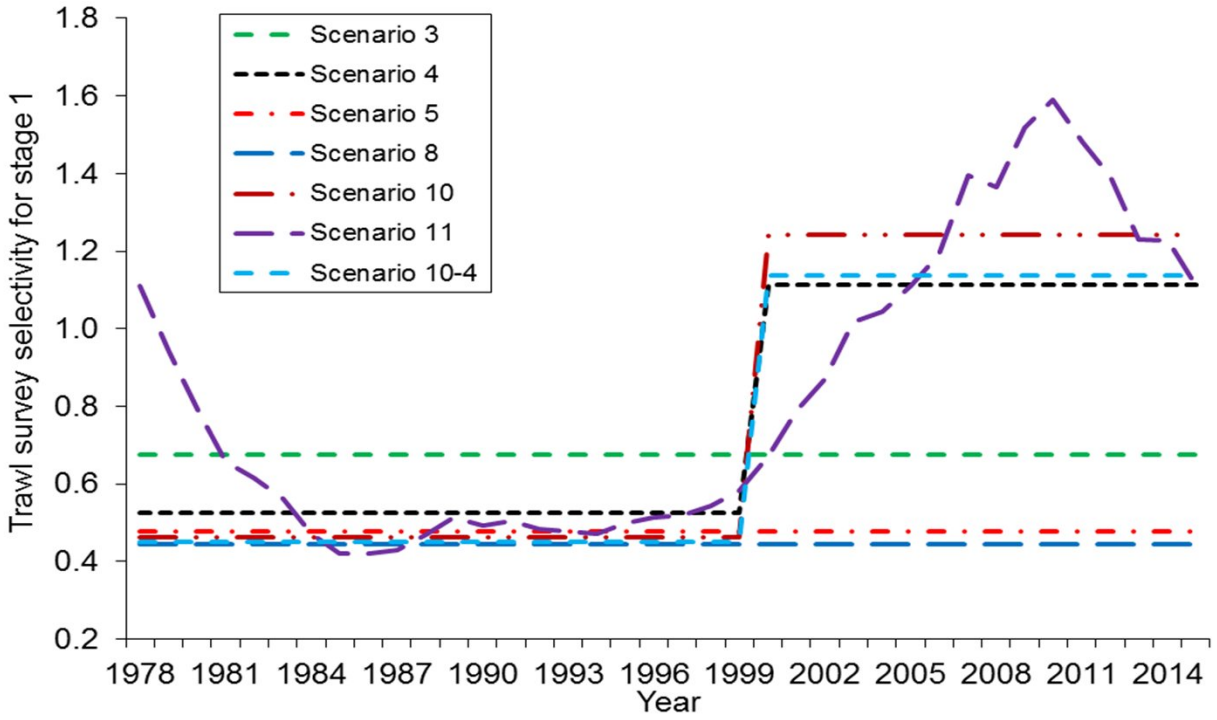
11. The same as scenario 10 except estimating annual trawl selectivity for stage 1 with a random walk approach (penalty weight = 50 for annual change).

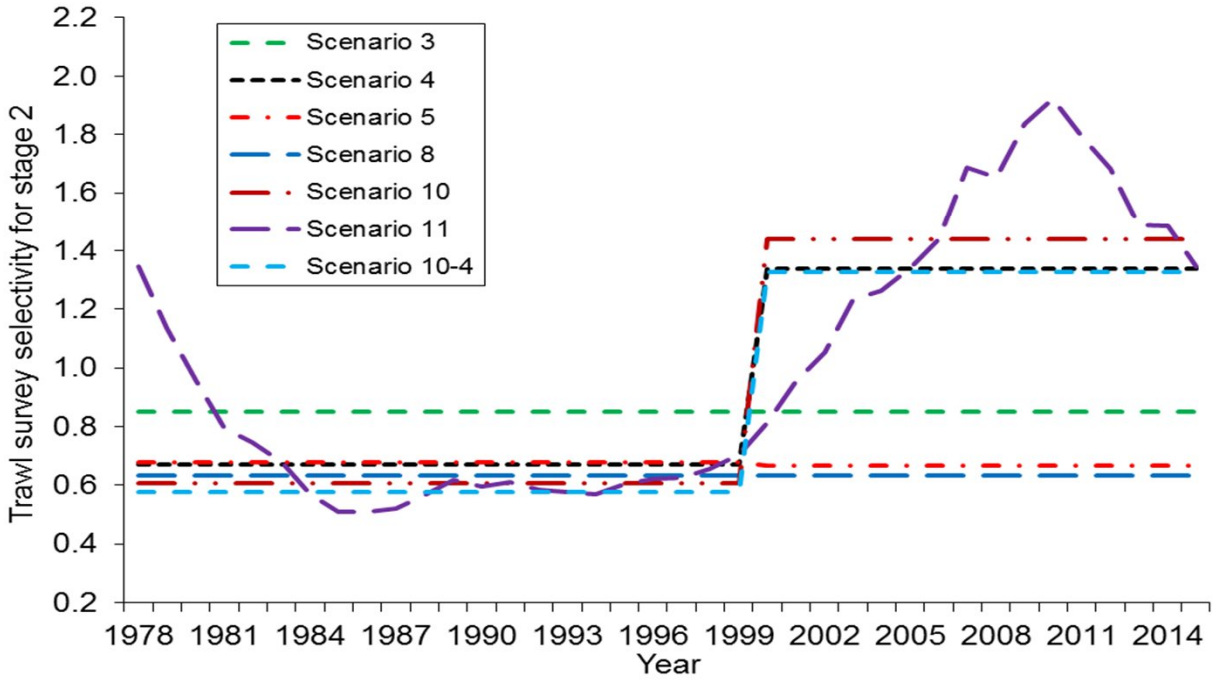
9-4 & 10-4. The same as scenarios 9 and 10 except reducing station R-24 trawl CPUE by multiplying a factor of 0.4*(401-25)/401, or 37.51%.

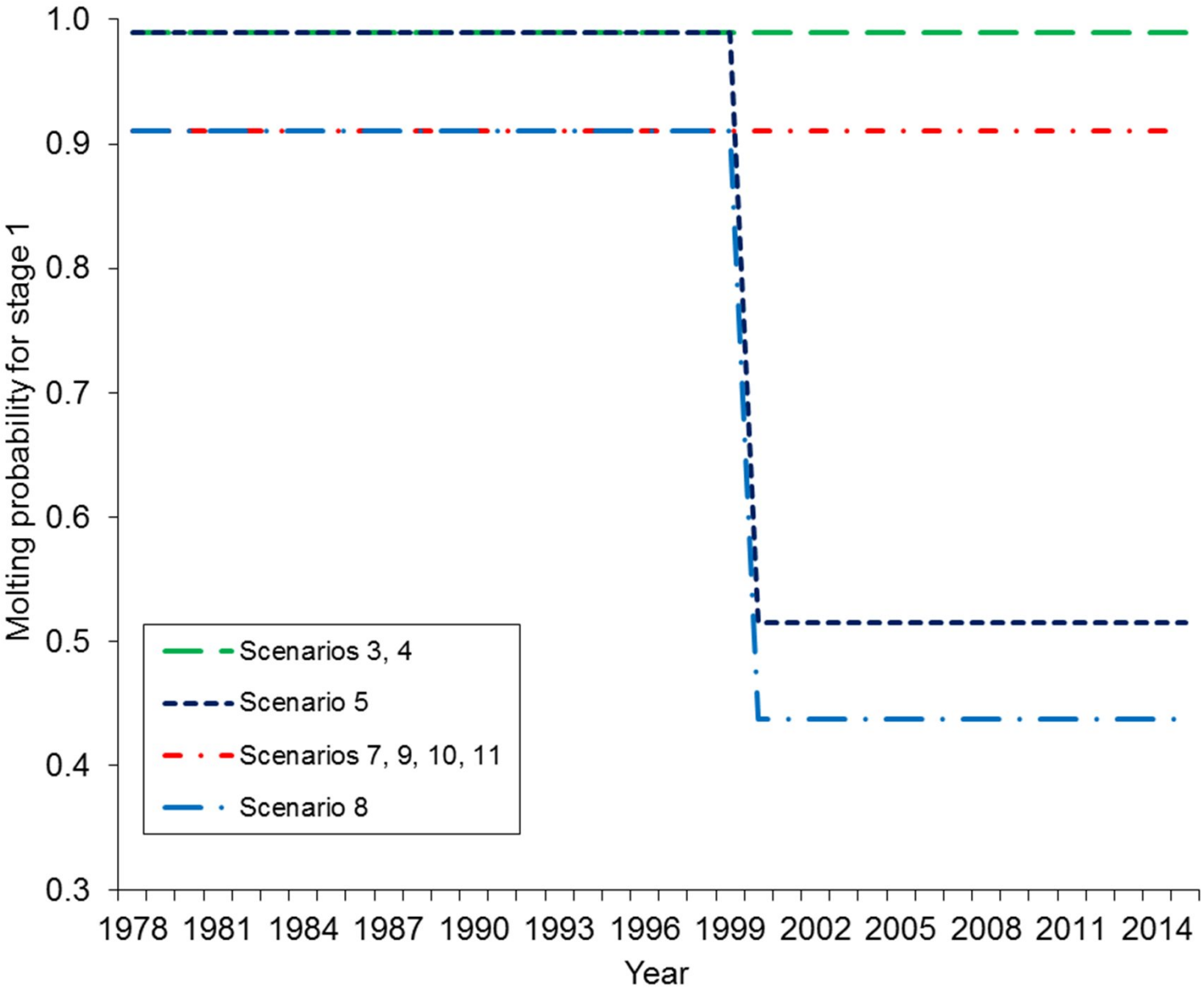
10-3. The same as scenario 10-4 except reduction factor is 0.3*(401-25)/401.

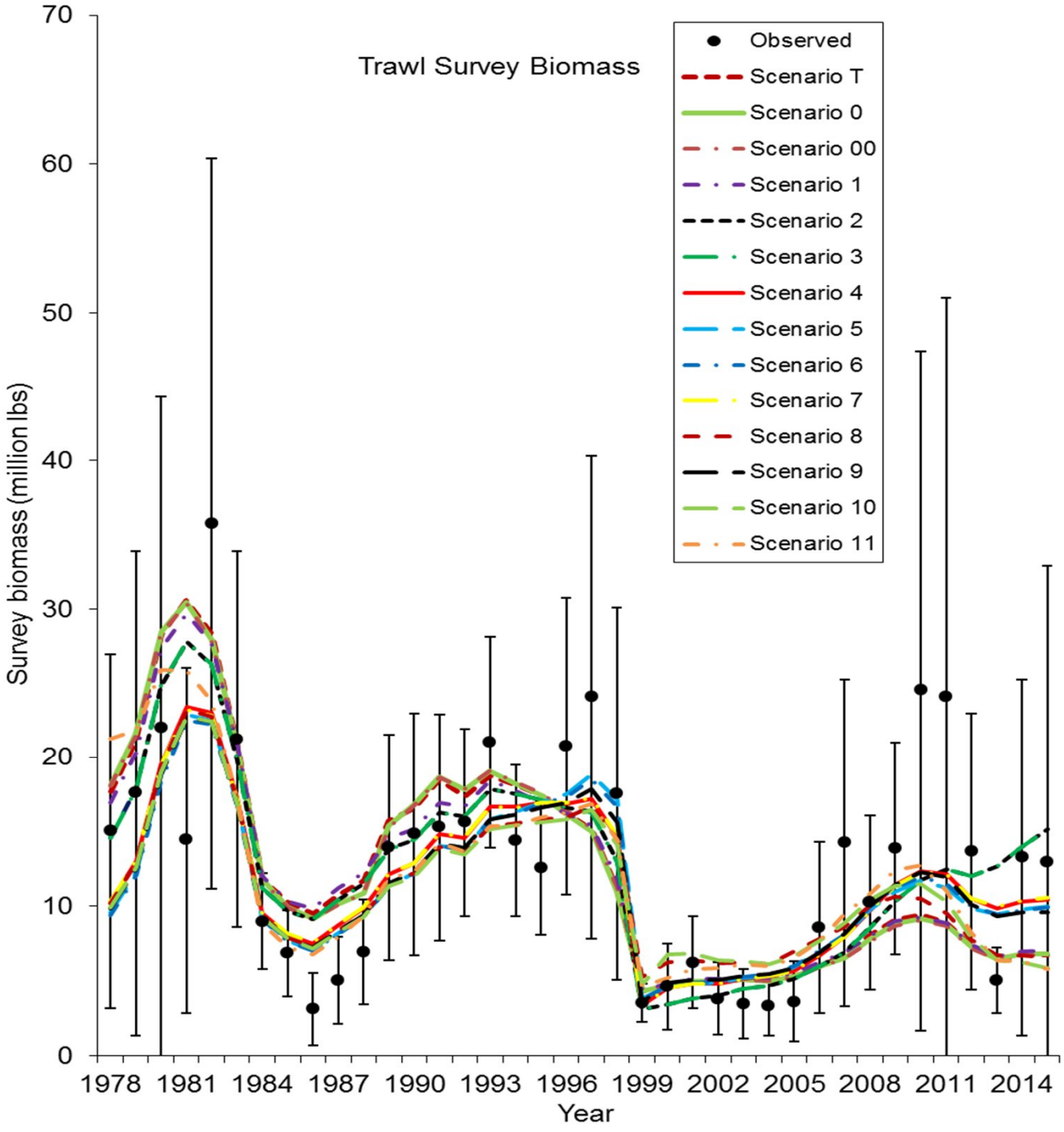
10-2. The same as scenario 10-4 except reduction factor is 0.2*(401-25)/401.

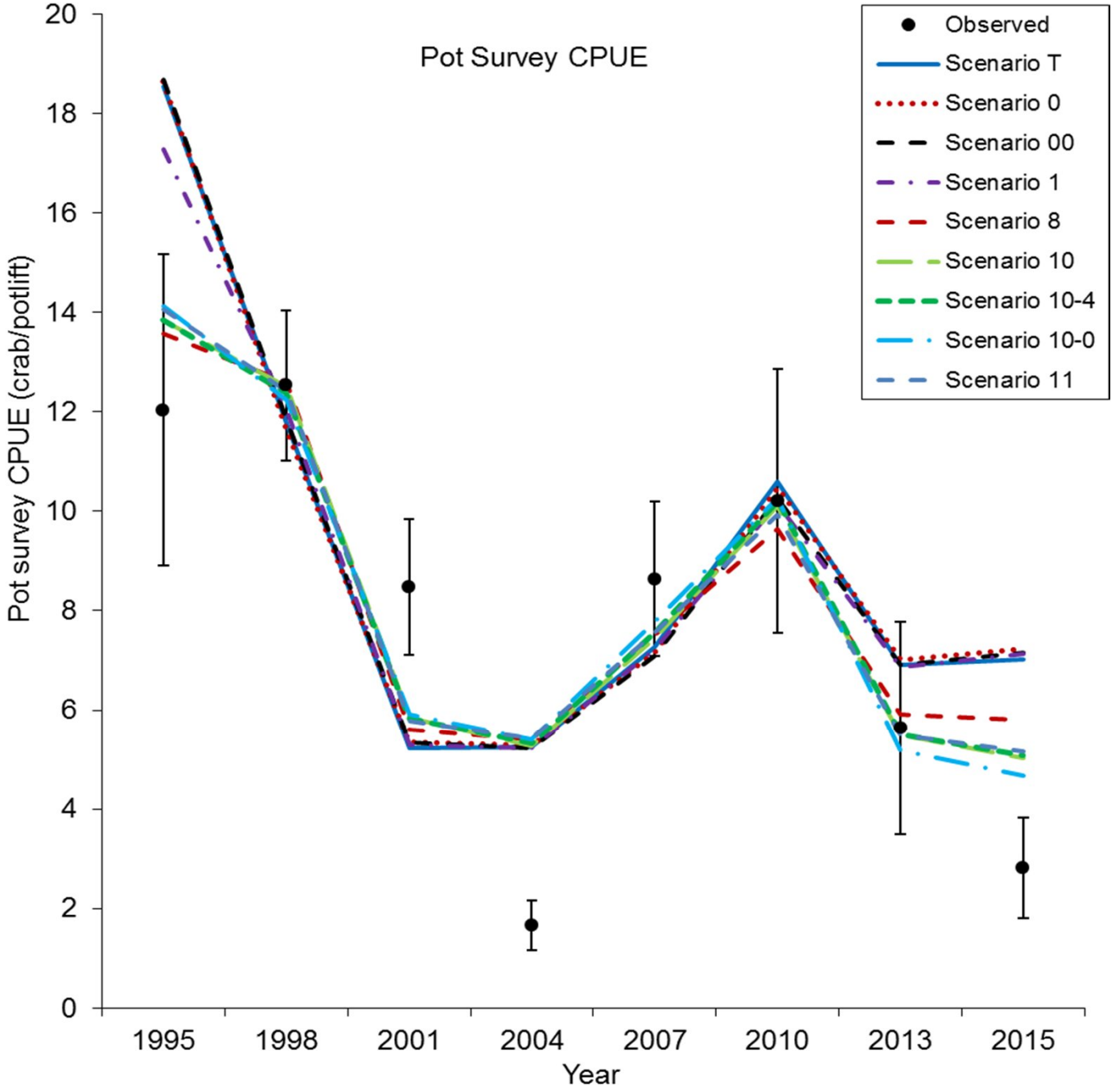
9-0 & 10-0. The same as scenarios 9-4 and 10-4 except assuming no trawl survey occurred in station R-24.

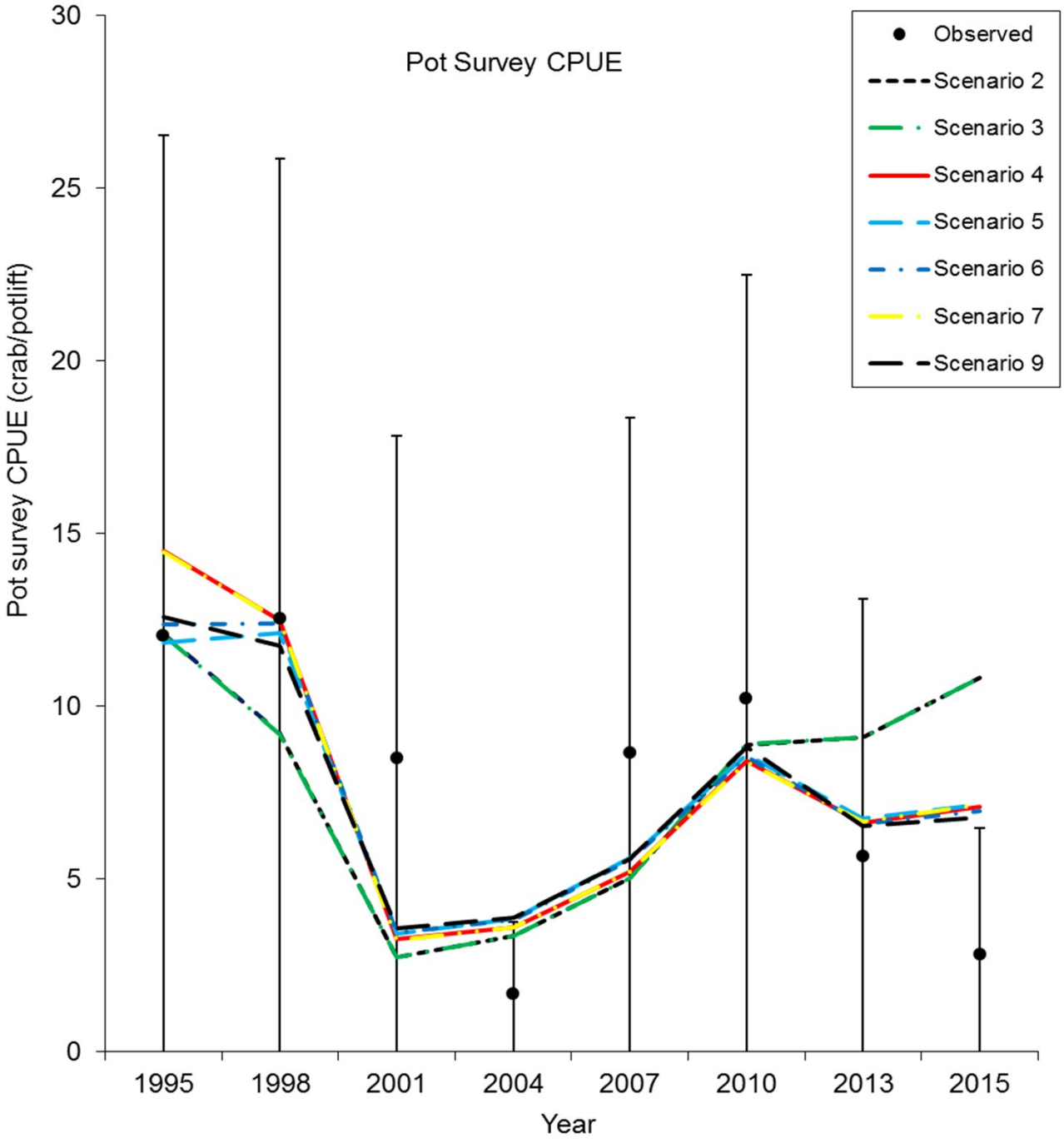

Scenario 3
Scenario 4
Scenario 5
Scenario 8
Scenario 10
Scenario 11
Scenario 10-4
Trawl survey selectivity for stage 1
Year
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008 2011 2014

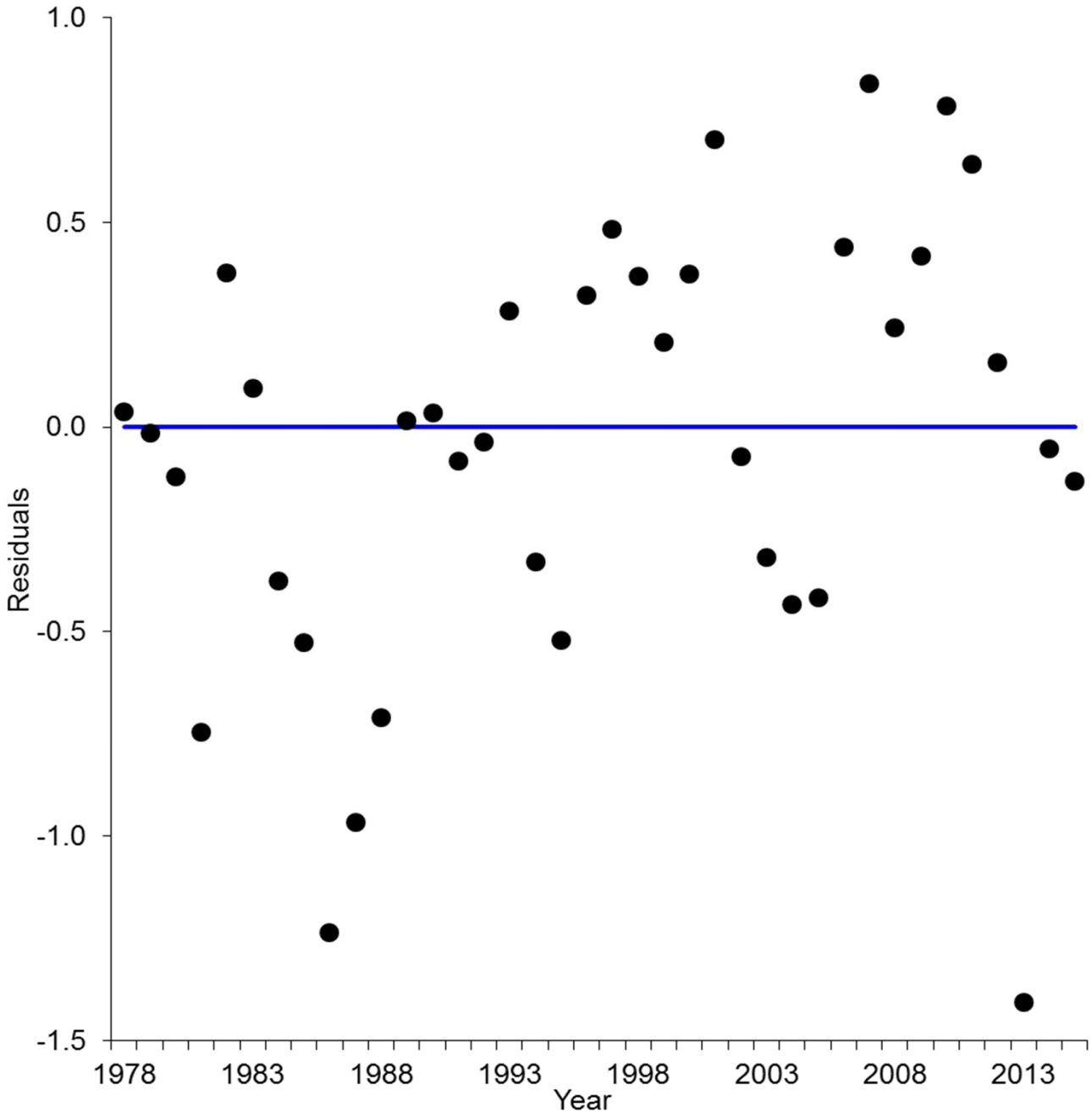

Scenario 3
Scenario 4
Scenario 5
Scenario 8
Scenario 10
Scenario 11
Scenario 10-4
Trawl survey selectivity for stage 2
Year
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008 2011 2014


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Molting probability for stage 1
Scenarios 3, 4
Scenario 5
Scenarios 7, 9, 10, 11
Scenario 8
1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008 2011 2014
Year

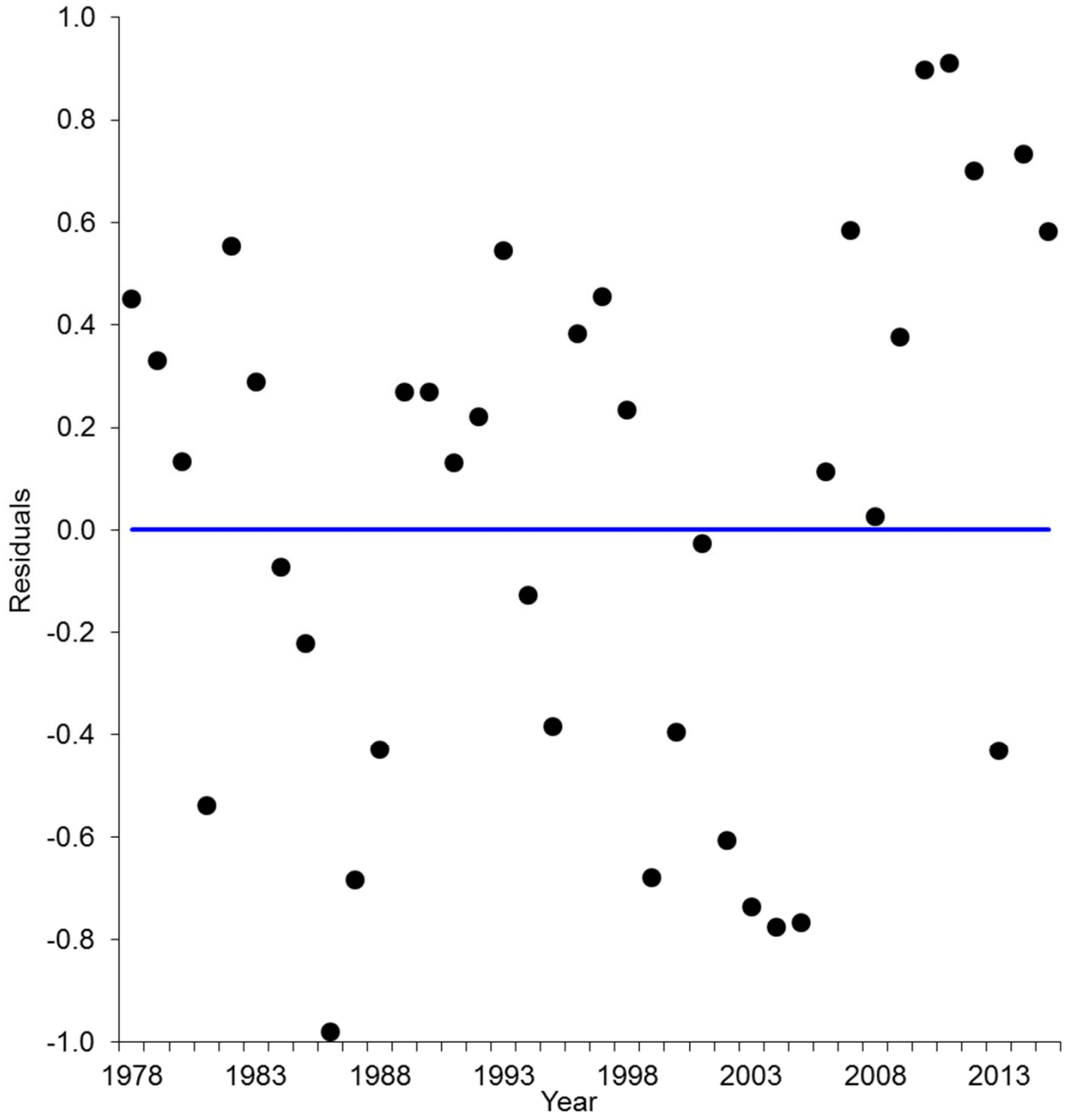

Trawl Survey Biomass
Observed
Scenario T
Scenario 0
Scenario 00
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11
Survey biomass (million lbs)
0
10
20
30
40
50
60
70
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
Year


Pot Survey CPUE
Observed
Scenario T
Scenario 0
Scenario 00
Scenario 1
Scenario 8
Scenario 10
Scenario 10-4
Scenario 10-0
Scenario 11
Pot survey CPUE (crab/potlift)
0
2
4
6
8
10
12
14
16
18
20
1995
1998
2001
2004
2007
2010
2013
2015
Year

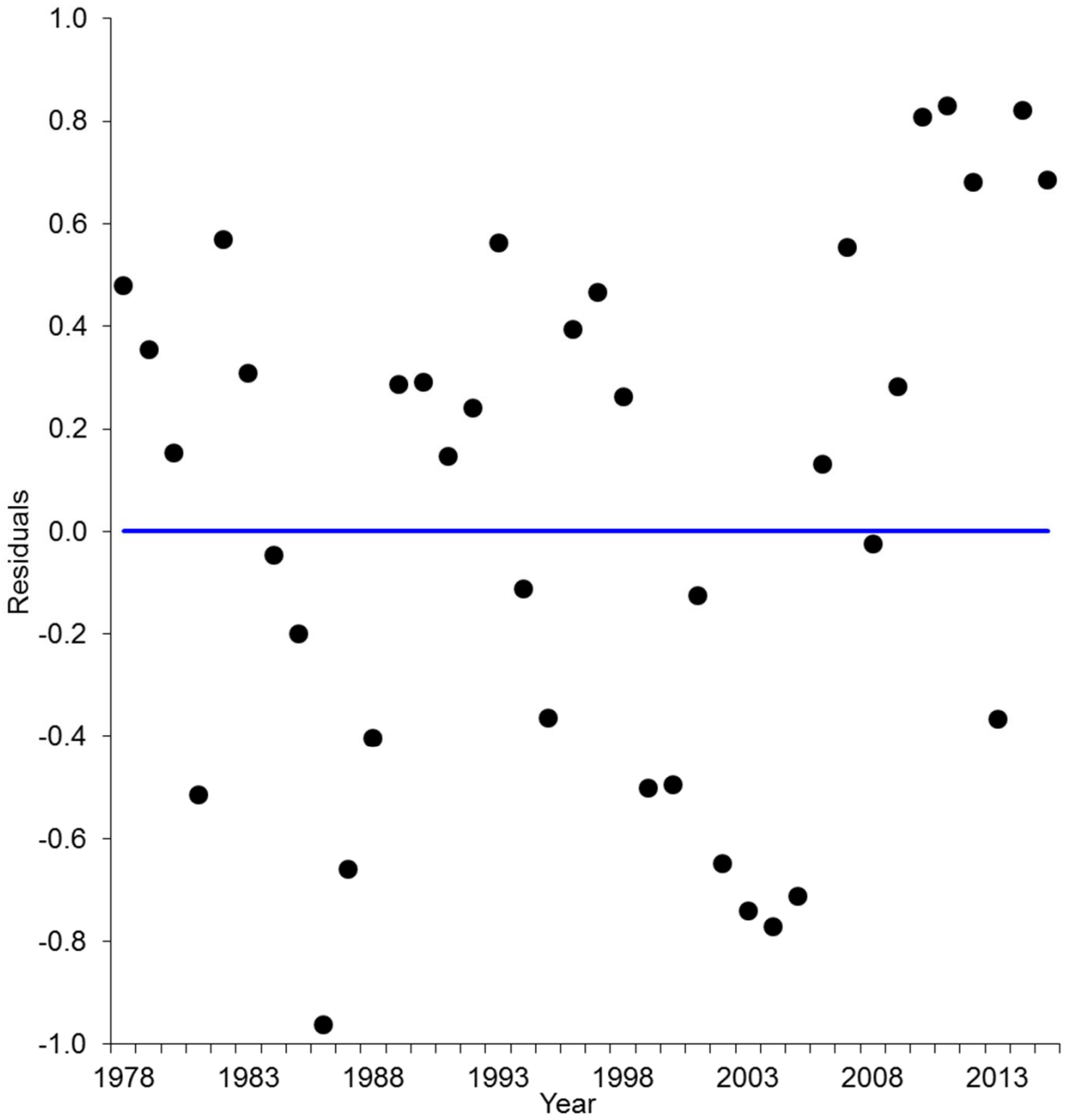

Pot Survey CPUE
Observed
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 9
Pot survey CPUE (crab/potlift)
0
5
10
15
20
25
30
1995
1998
2001
2004
2007
2010
2013
2015
Year



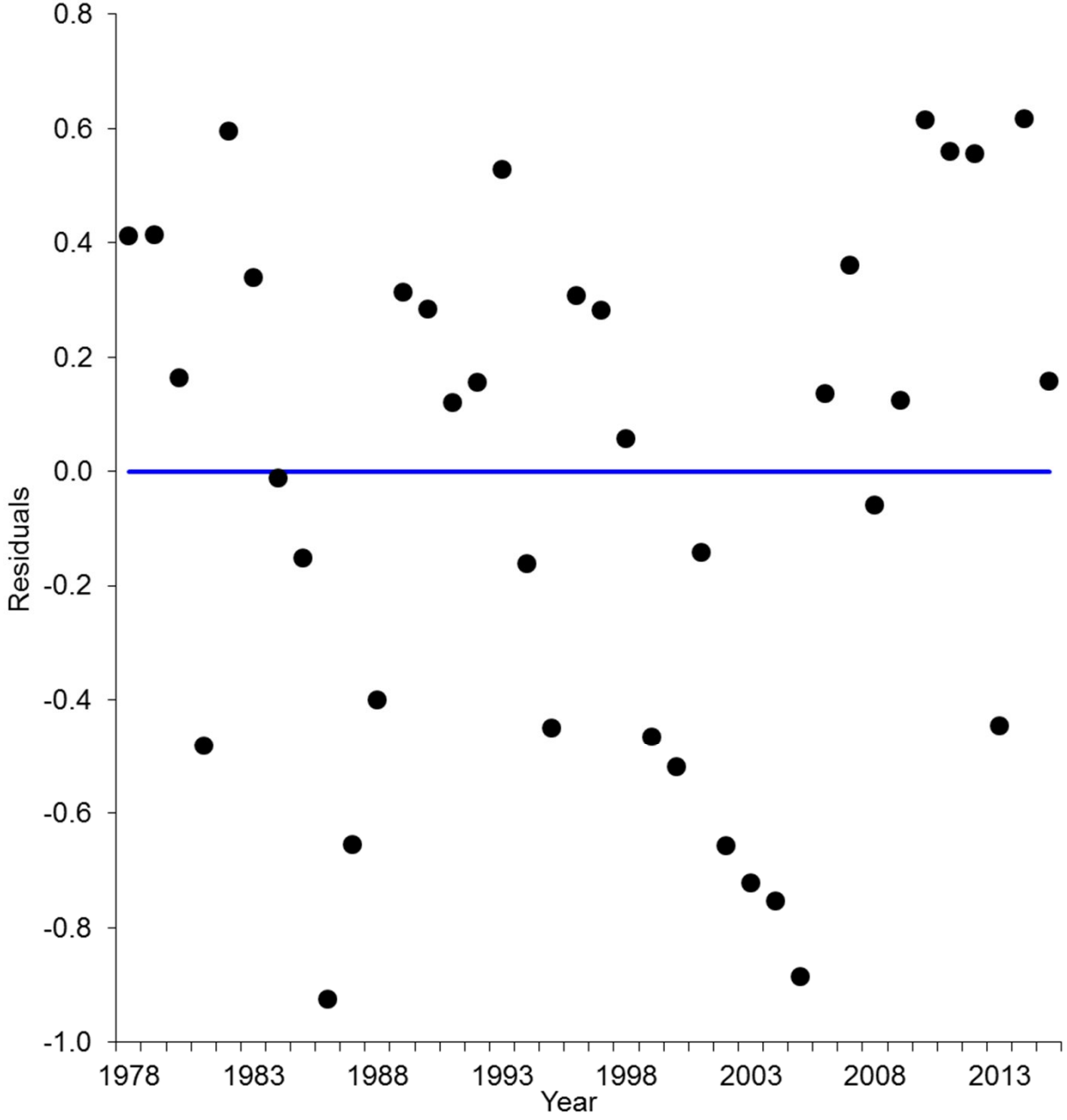
Trawl survey
Biomass residuals
Scenario 3



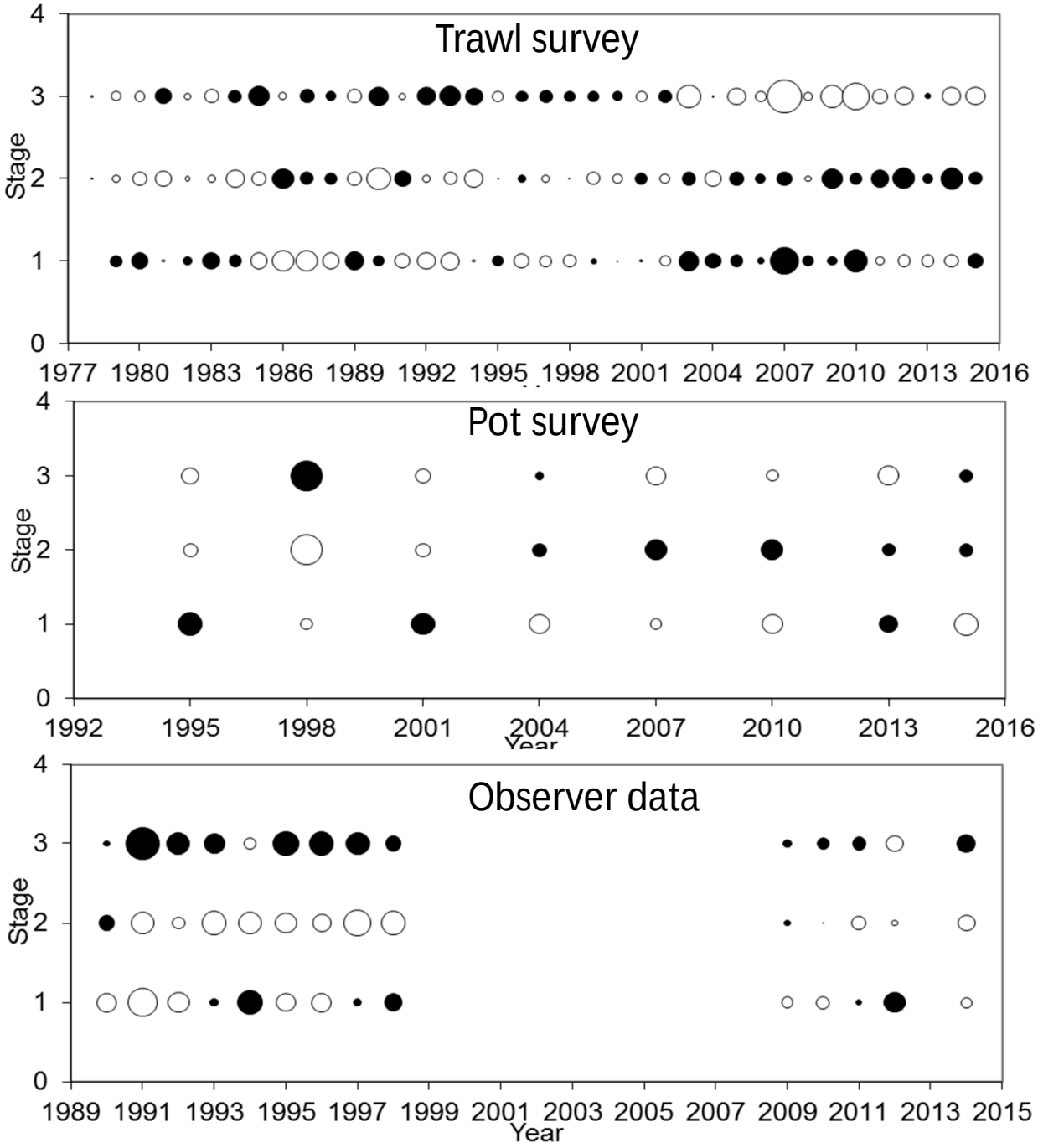
Trawl survey
Biomass residuals
Scenario 8



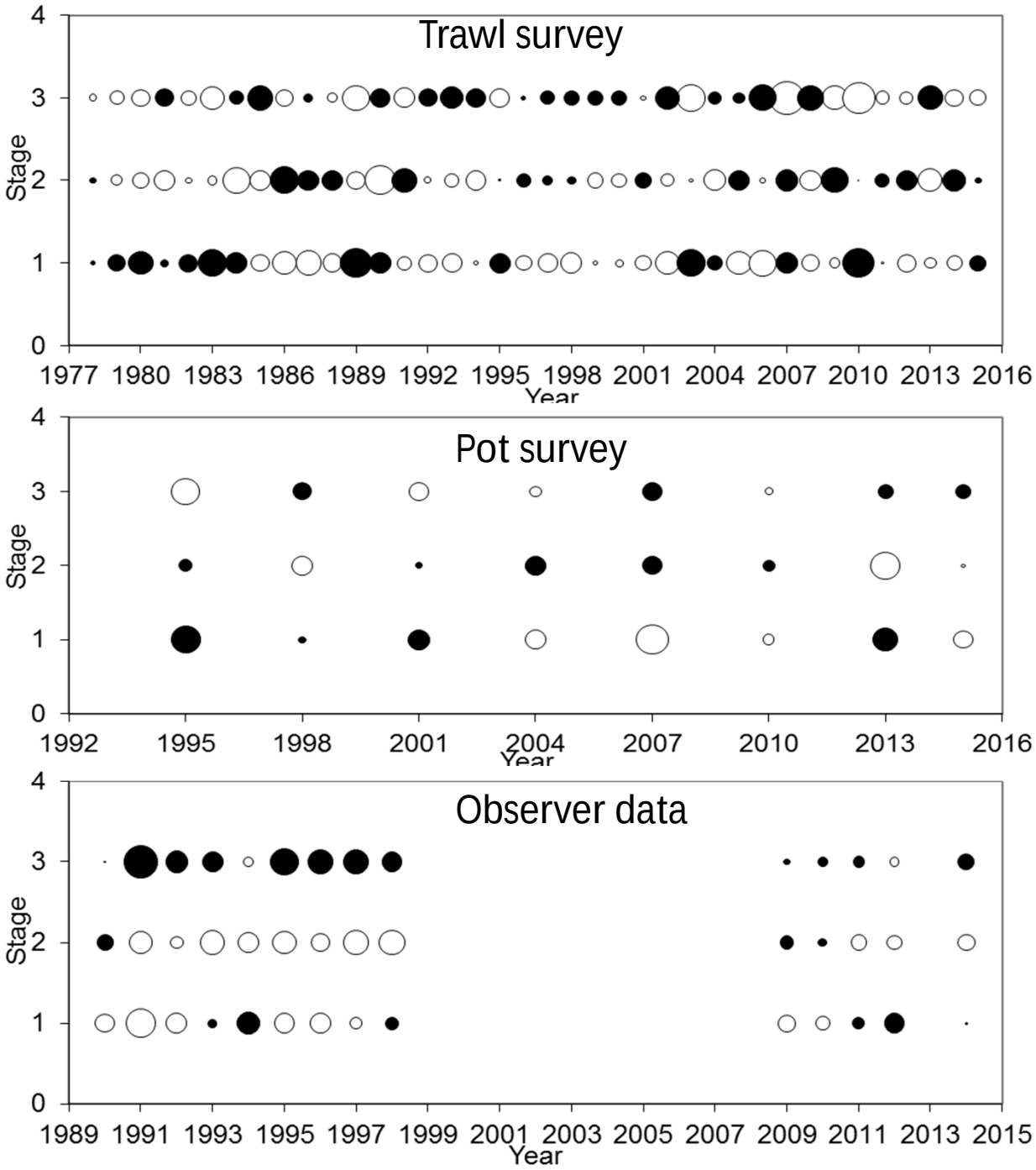
Trawl survey
Biomass residuals
Scenario 10



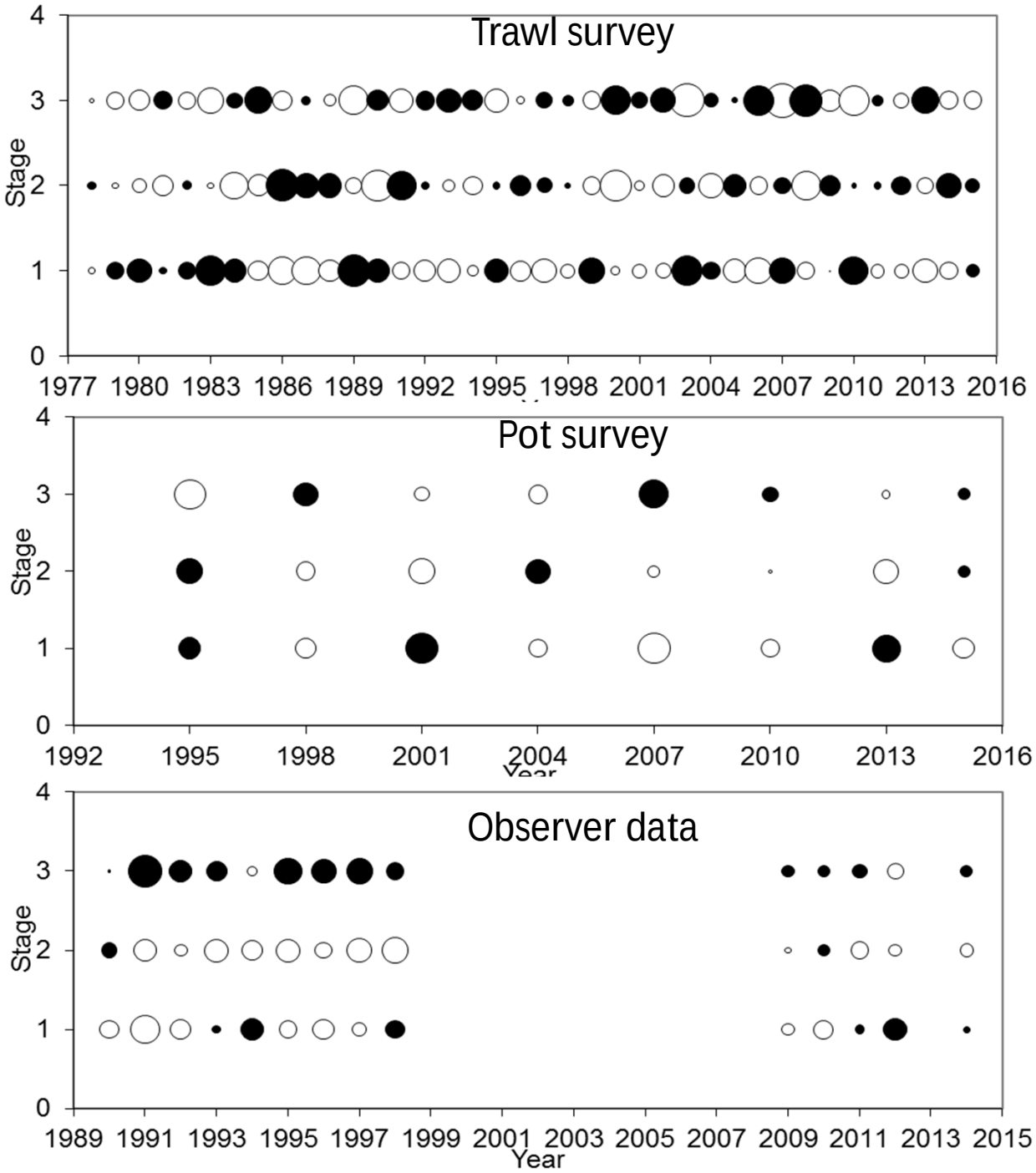
Trawl survey
Biomass residuals
Scenario 10-4



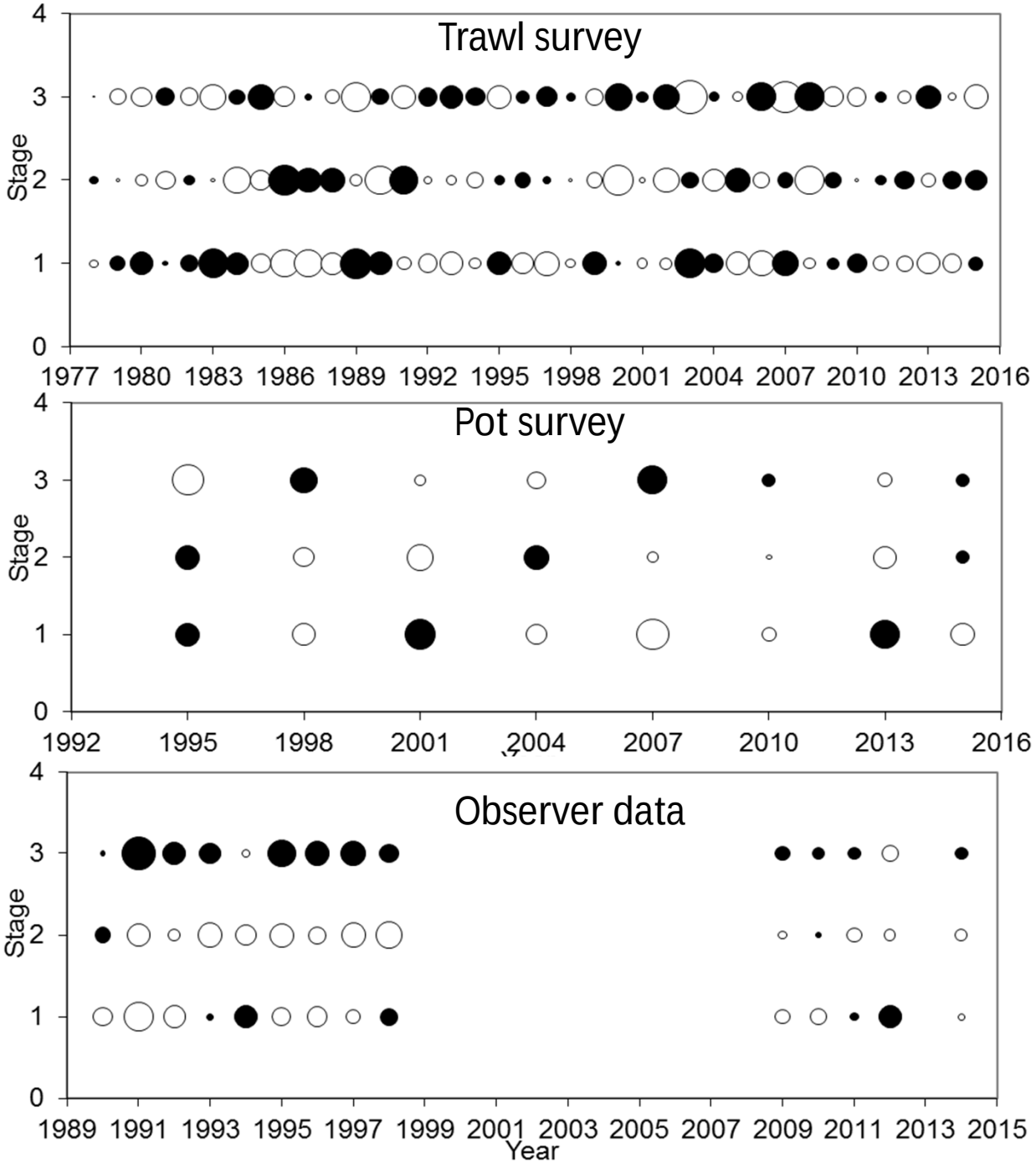
Residuals of Stage compositions Scenario 3



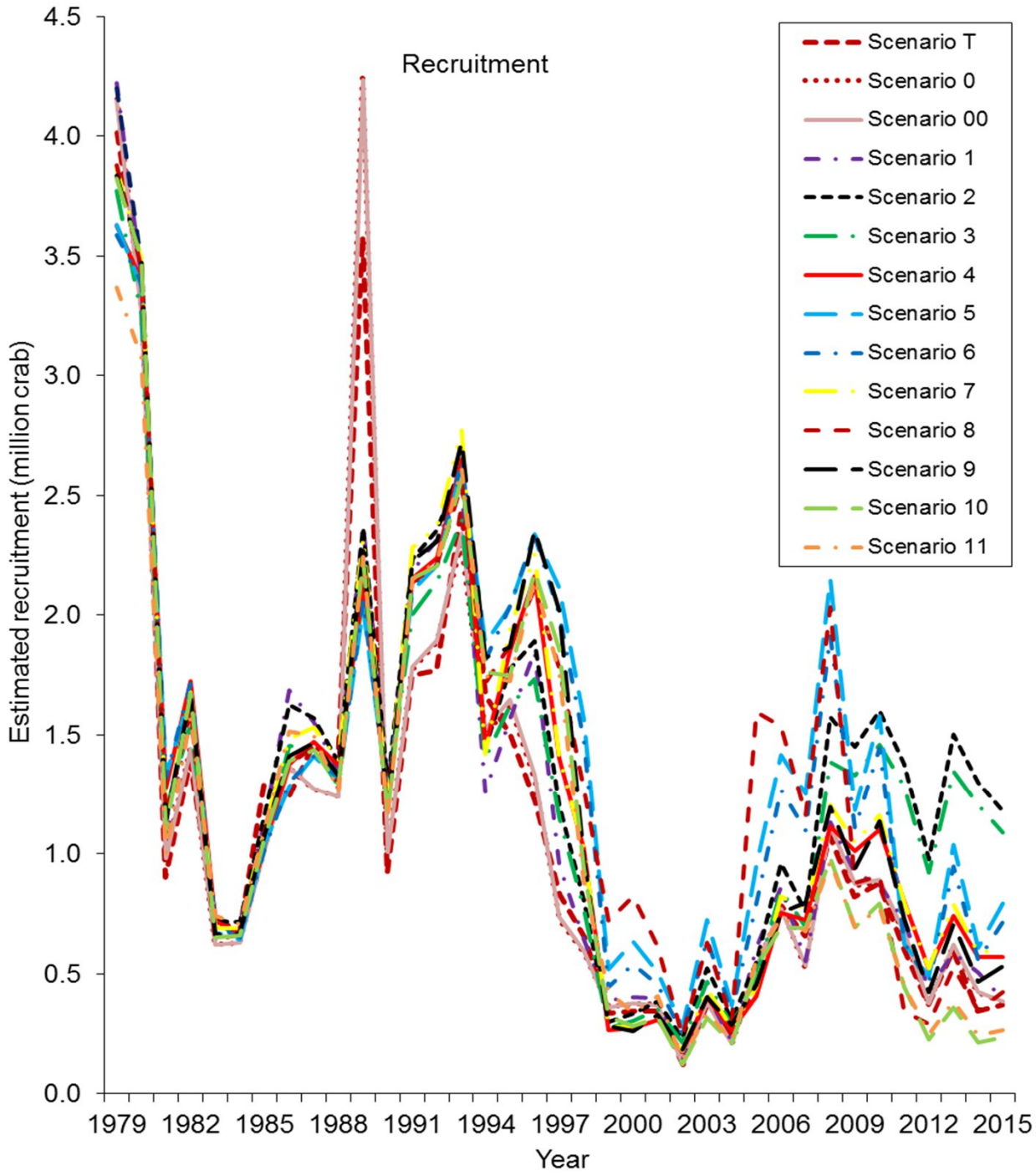
Residuals of
Stage compositions
Scenario 8

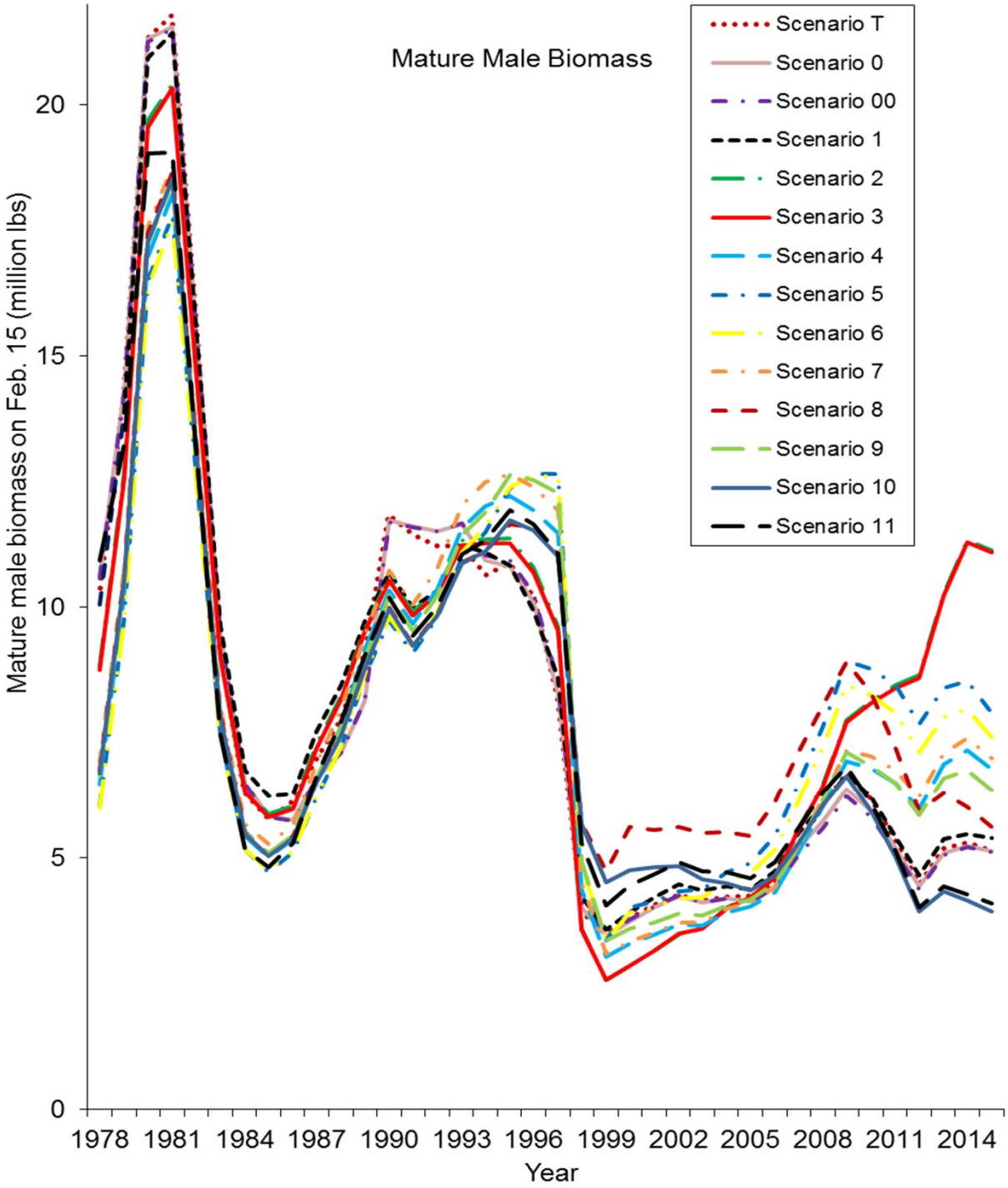


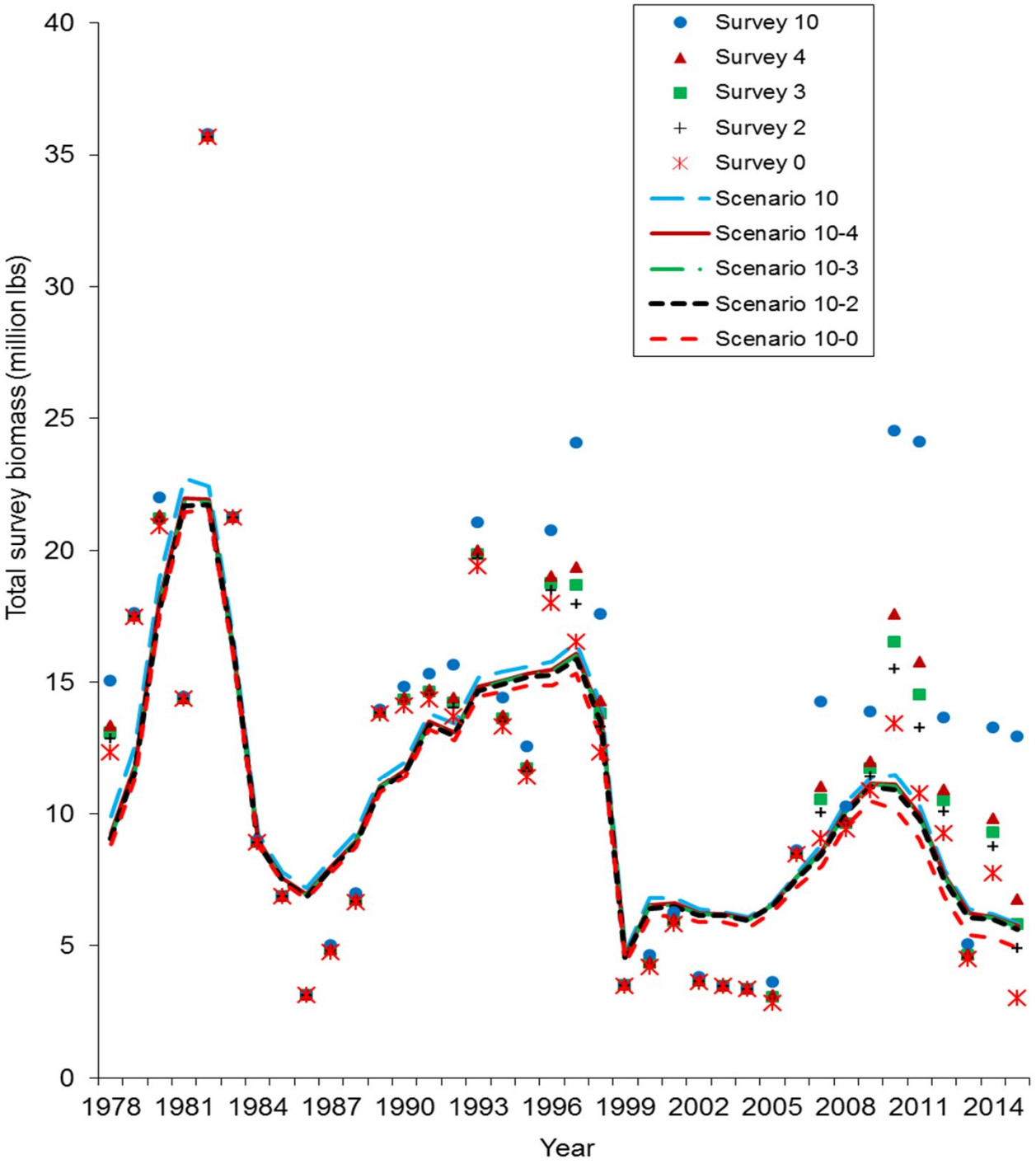
Residuals of
Stage compositions
Scenario 10



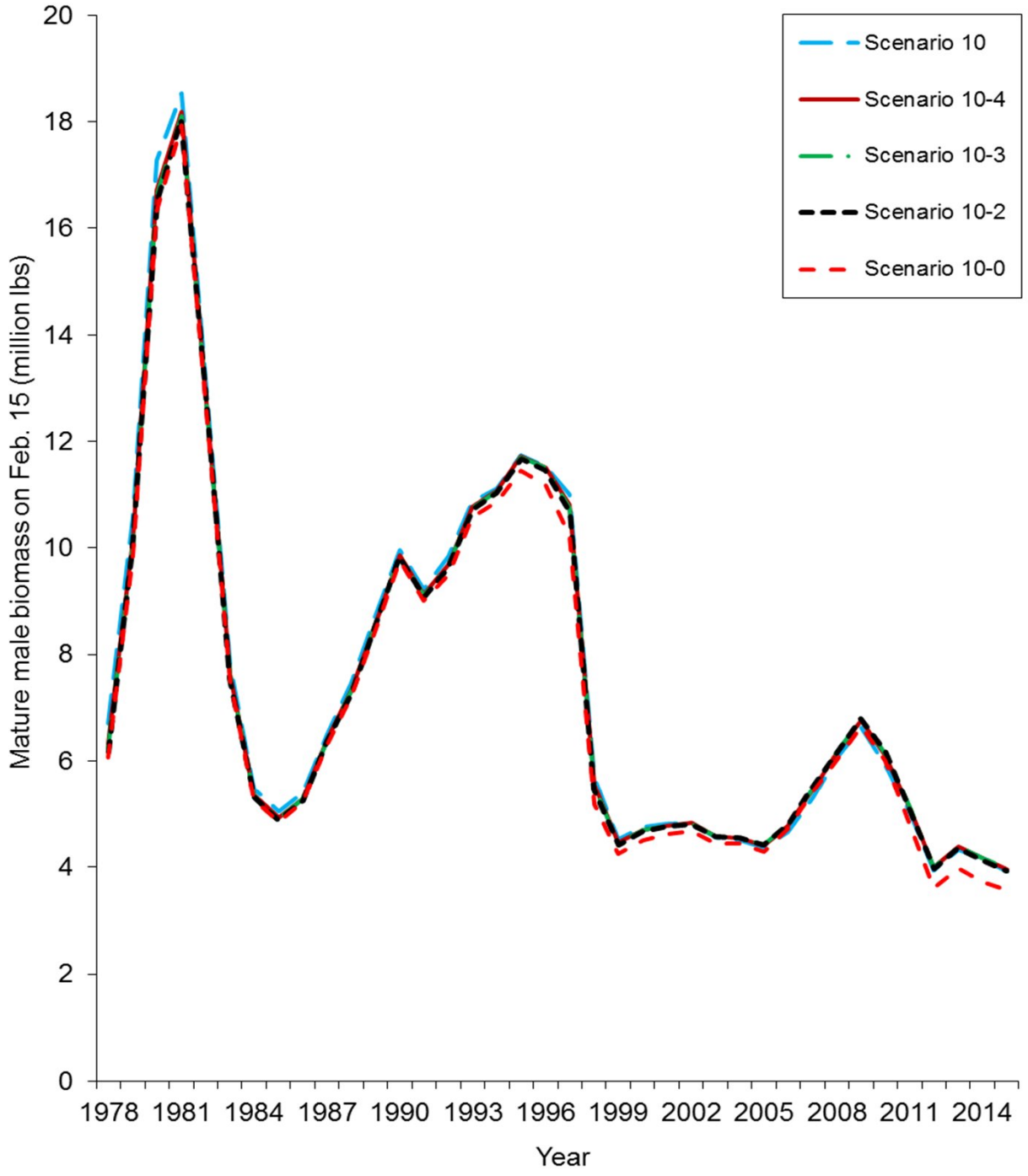
Residuals of
Stage compositions
Scenario 10-4

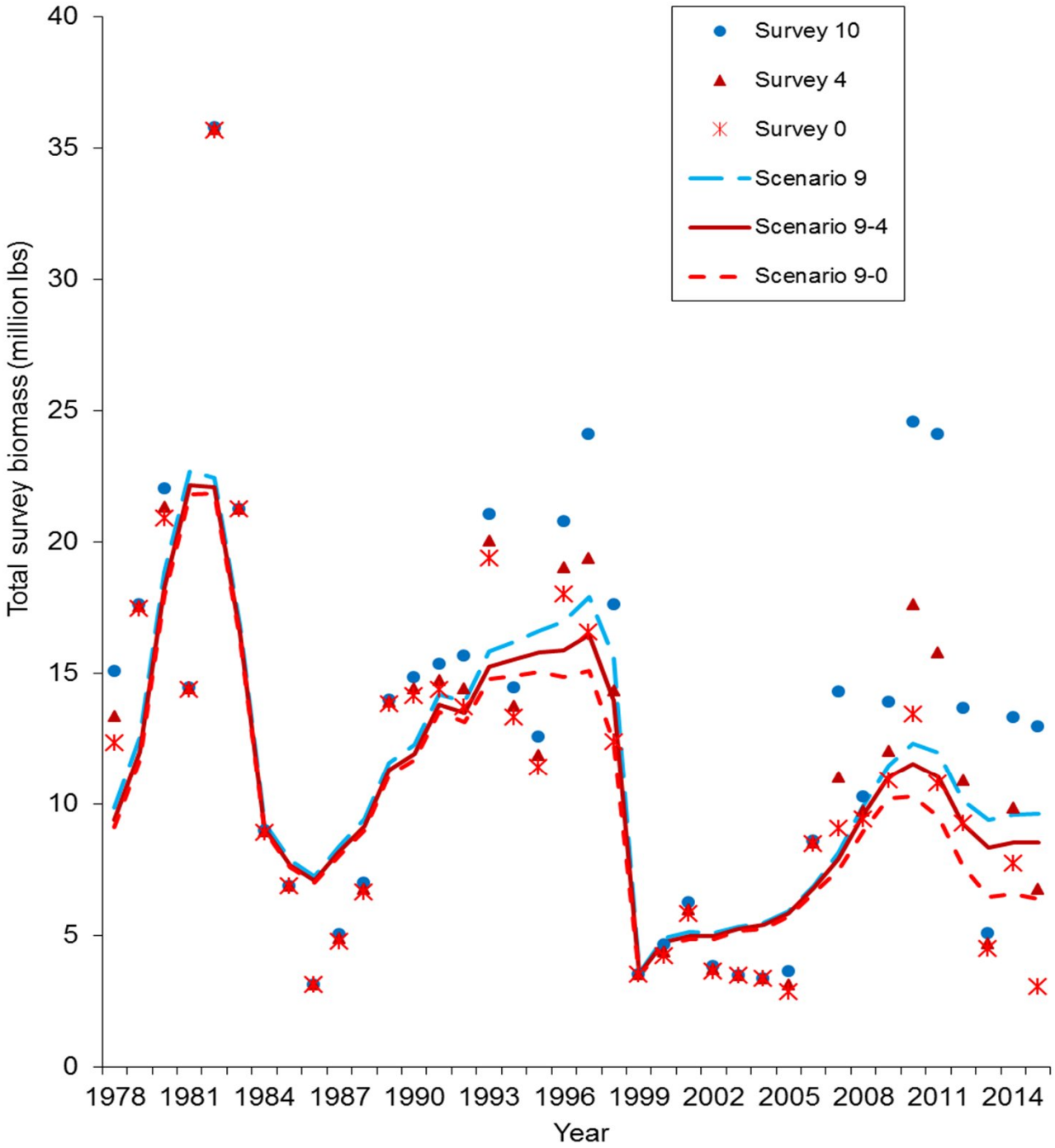

Recruitment
Estimated recruitment (million crab)
Year
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
Scenario T
Scenario 0
Scenario 00
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11


Mature Male Biomass
Mature male biomass on Feb. 15 (million lbs)
0
5
10
15
20
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
Year
Scenario T
Scenario 0
Scenario 00
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Scenario 10
Scenario 11



Survey 10, 4, 3, 2 and 0 denote area-swept estimates with 100%, 37.51%, 28.13%, 18.75%, and 0% of trawl survey station R-24 catch.


Scenario 10
Scenario 10-4
Scenario 10-3
Scenario 10-2
Scenario 10-0
Mature male biomass on Feb. 15 (million lbs)
0
2
4
6
8
10
12
14
16
18
20
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
Year



Impacts of additional CV for the pot survey CPUE

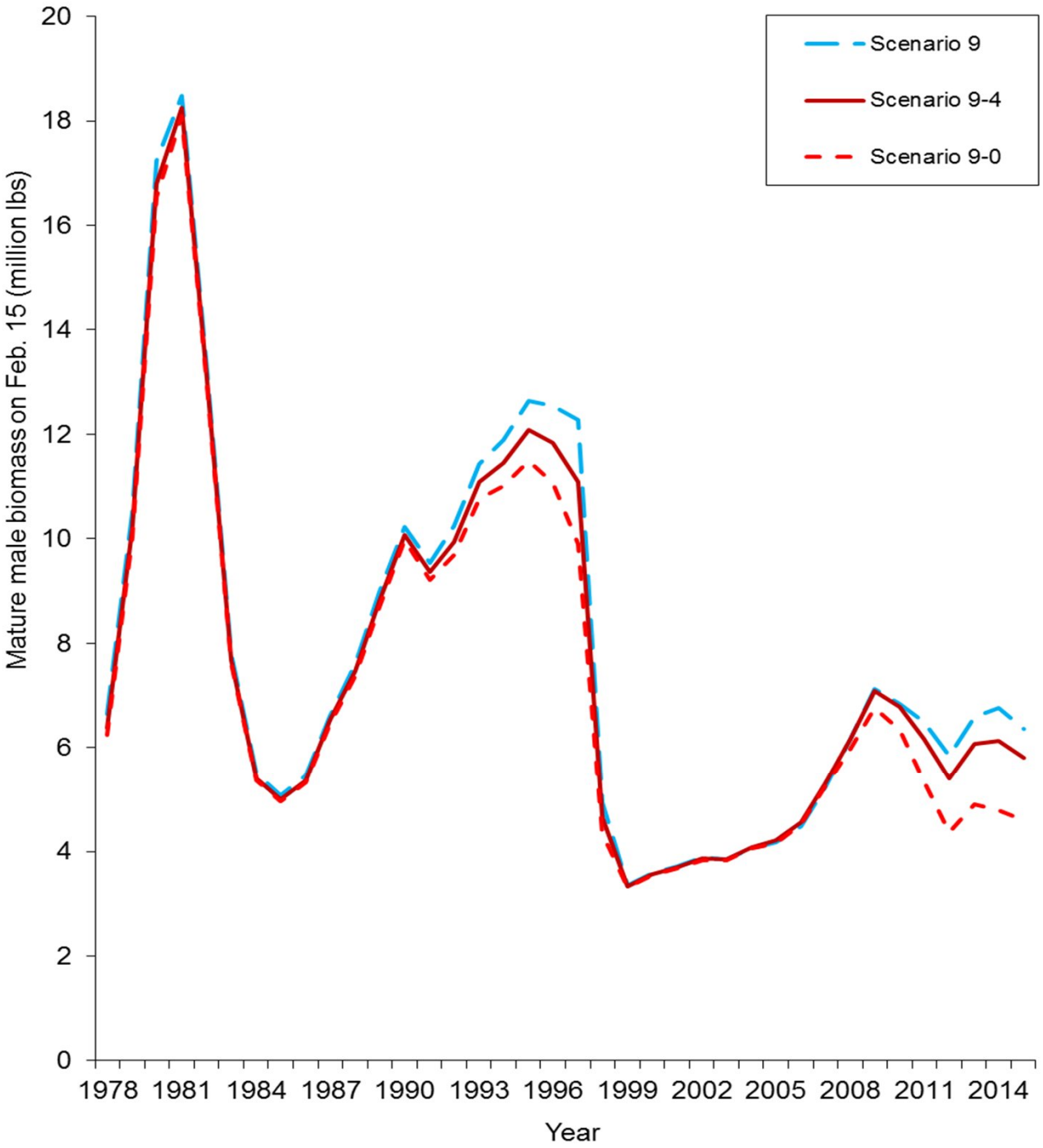

Scenario 9
Scenario 9-4
Scenario 9-0
Mature male biomass on Feb. 15 (million lbs)
0
2
4
6
8
10
12
14
16
18
20
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
Year

Table 10a. Comparisons of negative log-likelihood values and management measures for eighteen model scenarios.

Model Scenario

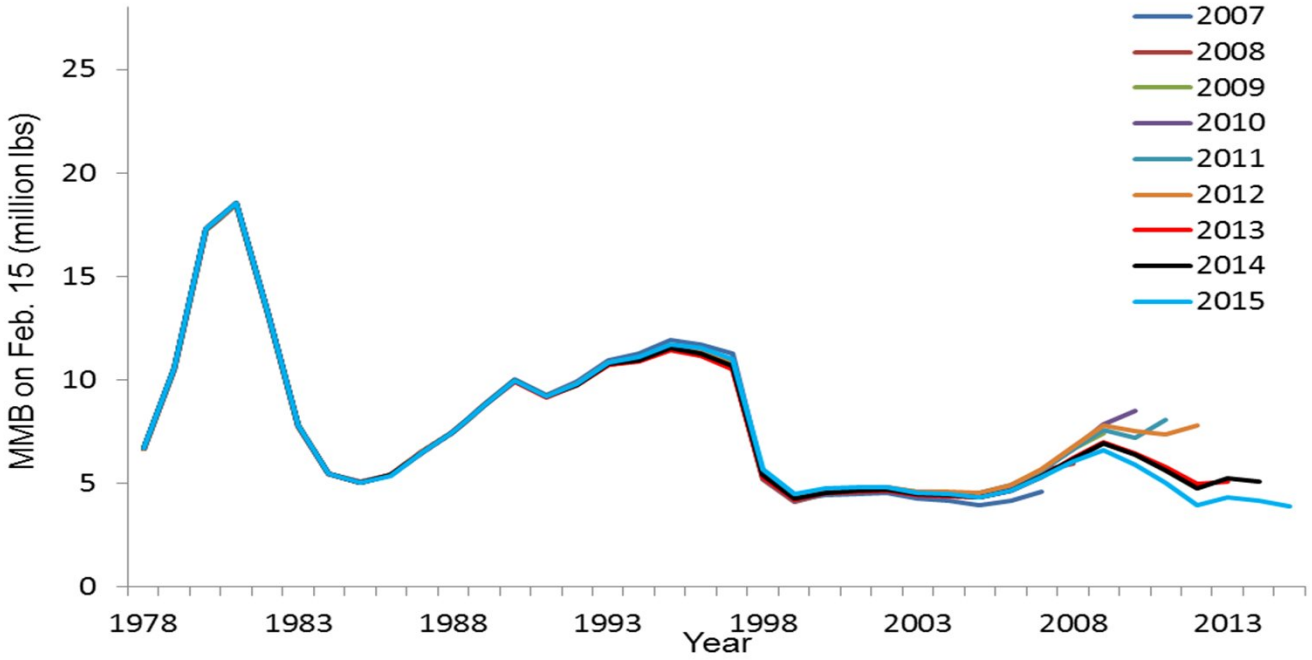
Neg.log.LL	T	0	00	1	2	3	4	5	6	7	8	9	10	11	10-0	10-2	10-3	10-4
Ret catch	0.595	0.497	0.449	0.638	0.462	0.462	0.415	0.416	0.418	0.420	0.436	0.425	0.445	0.458	0.458	0.460	0.459	0.458
Trawl bio	37.937	37.182	37.387	38.233	36.852	36.759	25.698	25.687	25.496	26.043	31.565	25.194	29.993	25.610	25.190	26.945	27.699	28.255
Pot CPUE	69.541	69.812	69.200	67.202	1.388	1.383	-0.322	-0.498	-0.579	-0.276	37.535	-0.755	30.644	33.196	29.943	31.353	31.382	31.290
Trawl length	1925.87	-132.49	-133.36	-128.50	-144.98	-144.84	-160.56	-161.25	-162.55	-160.72	-158.63	-161.75	-160.16	-163.02	-159.09	-161.15	-161.37	-161.42
Pot length	688.46	-47.82	-47.82	-45.58	-48.14	-48.23	-45.16	-45.63	-46.56	-44.97	-44.28	-48.99	-47.53	-48.31	-48.38	-48.12	-48.03	-47.95
Obser length	1307.40	-60.51	-60.78	-53.56	-53.93	-53.96	-53.64	-54.48	-54.38	-53.58	-54.24	-53.87	-53.73	-54.04	-54.54	-54.42	-54.36	-54.27
Obser Bio1				19.519	19.581	19.475	18.393	17.563	17.742	18.893	18.213	18.080	18.116	18.341	18.778	18.562	18.486	18.423
Obser Bio2				0.597	0.612	0.611	0.679	0.699	0.706	0.681	0.735	0.703	0.742	0.722	0.801	0.758	0.750	0.747
Trawl byc bio	17.495	17.503	0.171	0.171	0.167	0.167	0.171	0.171	0.172	0.171	0.174	0.173	0.178	0.176	0.177	0.177	0.177	0.178
Fix-g. byc bio	17.752	17.909	0.348	0.345	0.162	0.174	0.092	0.087	0.087	0.092	0.087	0.087	0.087	0.087	0.089	0.088	0.088	0.088
Tem. Dev.														8.524				
Rec Pen	13.747	13.667	13.776	13.009	10.671	10.614	12.885	8.825	9.677	12.897	11.595	13.686	17.933	15.513	18.474	17.421	17.401	17.470
Direct F pen	0.012	0.012	0.012	0.012	0.013	0.013	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.013	0.011	0.011	0.011	0.011
Trawl by F per	13.545	13.557	0.961	0.966	0.946	0.948	0.972	0.973	0.974	0.970	0.987	0.984	1.053	1.043	1.045	1.048	1.049	1.050
Fix-g by F pen	16.136	16.302	0.869	0.868	0.891	0.893	0.873	0.811	0.822	0.874	0.780	0.863	0.863	0.862	0.854	0.856	0.857	0.858
Total	4108.48	-54.39	-118.78	-86.09	-175.30	-175.53	-199.49	-206.61	-207.96	-198.49	-155.02	-205.16	-161.36	-160.83	-166.18	-166.01	-165.40	-164.81
Total est para	126	126	126	128	129	130	132	131	133	131	129	133	132	167	132	132	132	132
Bmsy (mill.lbs)	8.146	8.081	8.069	8.185	8.457	8.402	7.743	8.138	7.997	8.0235	8.288	7.863	7.62	7.925	7.343	7.497	7.527	7.543
MMB2015	5.139	5.132	5.117	5.396	11.131	11.086	6.775	7.901	7.409	7.001	5.604	6.349	3.922	4.091	3.564	3.932	3.968	3.966
OFL2015	0.532	0.558	0.554	0.617	1.986	1.986	1.094	1.182	1.098	1.103	0.53	0.929	0.344	0.357	0.289	0.352	0.357	0.356
Fofl	0.106	0.107	0.107	0.112	0.18	0.18	0.155	0.174	0.165	0.155	0.115	0.141	0.083	0.083	0.077	0.085	0.085	0.085

Table 10b. Comparisons of differences of negative log-likelihood values and number of parameters between different model scenarios.

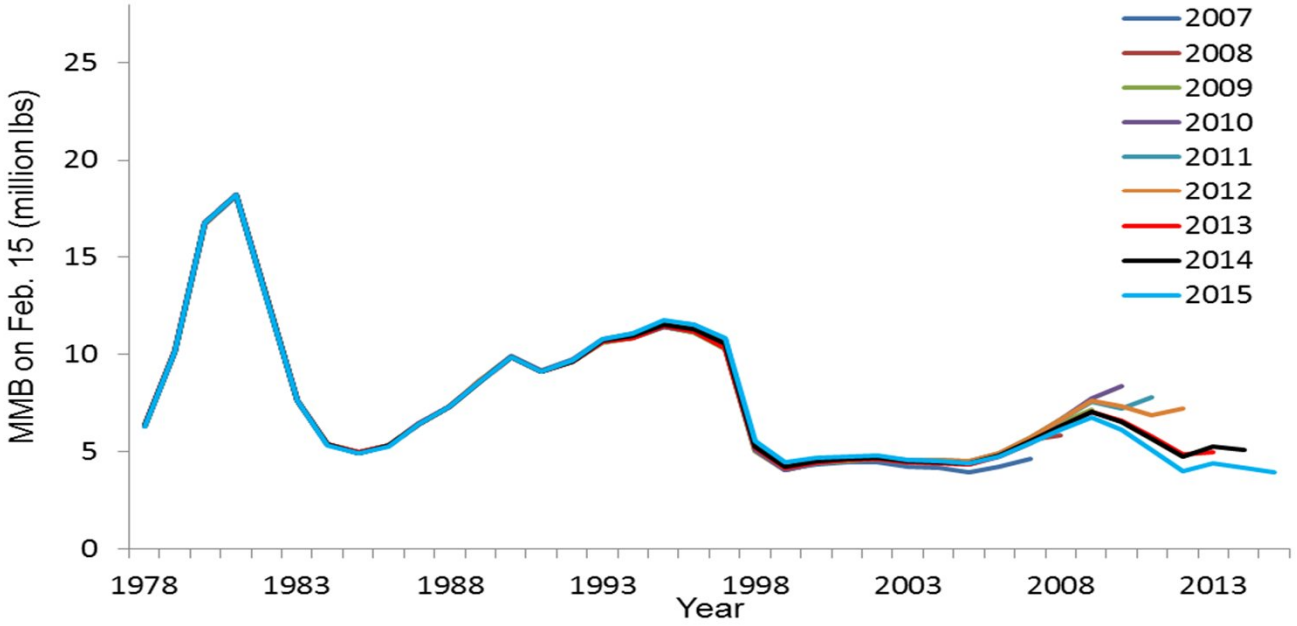
	Model Scenario											
Neg.log.LL	2 - 1	3 - 2	4 - 3	5 - 4	6 - 4	7 - 4	8 - 5	9 - 7	10 - 9	10 - 7	8 - 10	11 - 10
Ret catch	-0.176	0.000	-0.047	0.001	0.003	0.005	0.019	0.005	0.020	0.025	-0.010	0.013
Trawl bio	-1.381	-0.092	-11.061	-0.011	-0.202	0.345	5.878	-0.849	4.799	3.950	1.572	-4.383
Pot CPUE	-65.814	-0.004	-1.705	-0.176	-0.257	0.046	38.033	-0.479	31.399	30.920	6.890	2.552
Trawl length	-16.480	0.148	-15.725	-0.688	-1.984	-0.160	2.622	-1.026	1.587	0.561	1.533	-2.863
Pot length	-2.557	-0.097	3.076	-0.469	-1.408	0.190	1.350	-4.027	1.466	-2.561	3.252	-0.782
Obser length	-0.362	-0.038	0.320	-0.834	-0.732	0.062	0.242	-0.289	0.137	-0.152	-0.502	-0.305
Obser Bio1	0.062	-0.106	-1.083	-0.830	-0.650	0.500	0.650	-0.813	0.036	-0.777	0.096	0.225
Obser Bio2	0.015	-0.001	0.068	0.020	0.028	0.002	0.036	0.021	0.040	0.061	-0.007	-0.020
Trawl byc bio	-0.004	0.000	0.004	0.000	0.000	0.000	0.003	0.002	0.005	0.007	-0.004	-0.001
Fix-g. byc bio	-0.183	0.012	-0.082	-0.005	-0.005	-0.001	0.000	-0.004	0.000	-0.004	0.000	-0.001
Tem. Dev.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.524
Rec Pen	-2.338	-0.056	2.271	-4.060	-3.208	0.012	2.770	0.788	4.247	5.036	-6.338	-2.420
Direct F pen	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Trawl by F pen	-0.020	0.002	0.024	0.001	0.002	-0.002	0.014	0.014	0.070	0.083	-0.066	-0.011
Fix-g by F pen	0.023	0.001	-0.019	-0.063	-0.052	0.001	-0.031	-0.011	0.000	-0.011	-0.083	-0.001
Total	-89.213	-0.231	-23.961	-7.115	-8.464	1.000	51.584	-6.668	43.804	37.136	6.333	0.529
Diff para.	1	1	2	-1	1	-1	-2	2	-1	1	-3	35

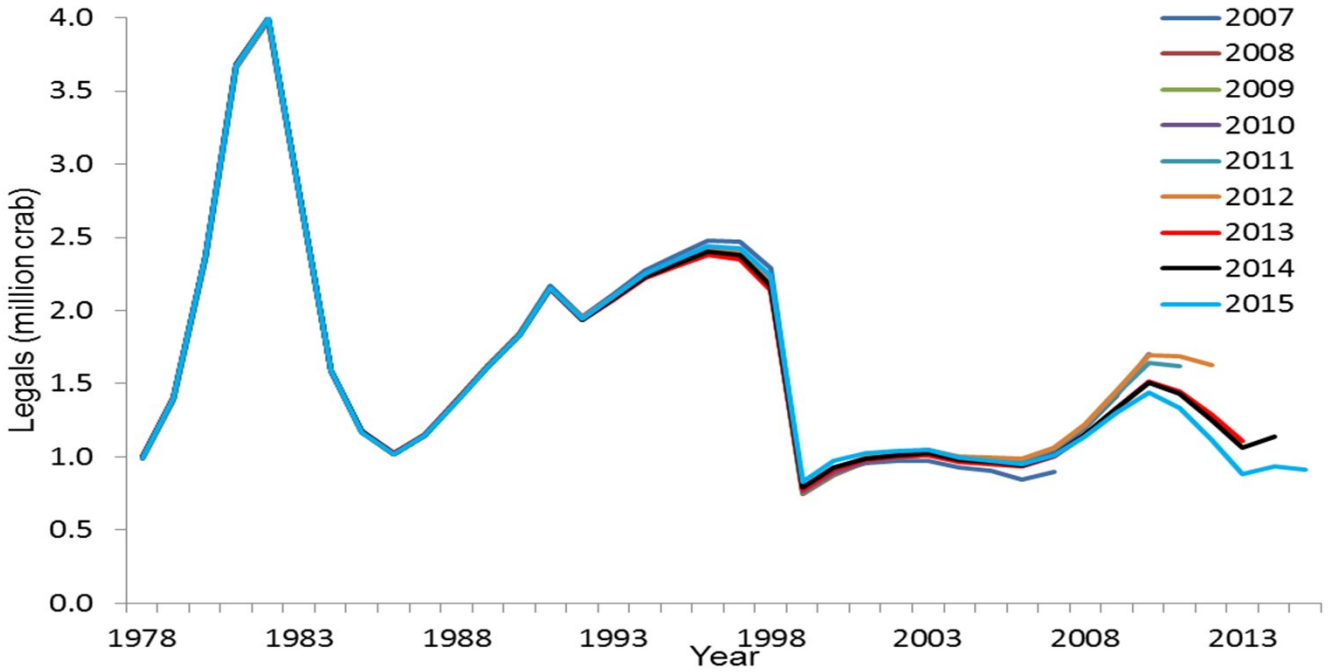
2015 model Results

Scen.10



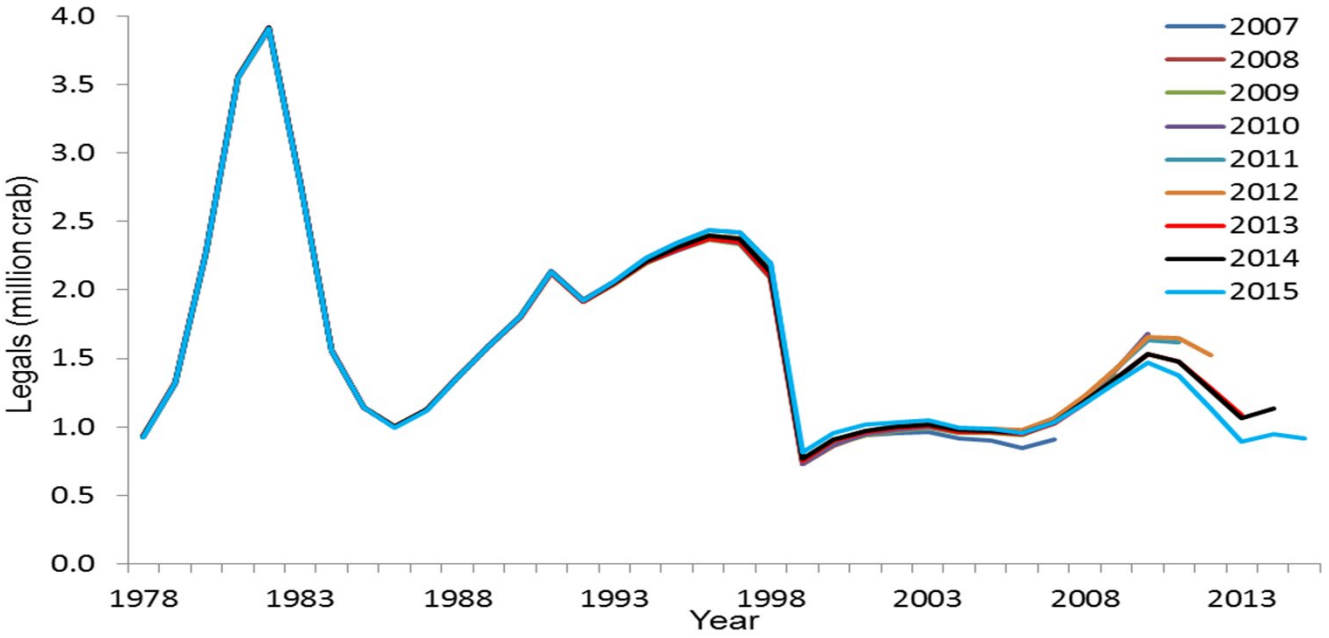
Scen.10-4





2015 model Results

Scen.10



Scen.10-4

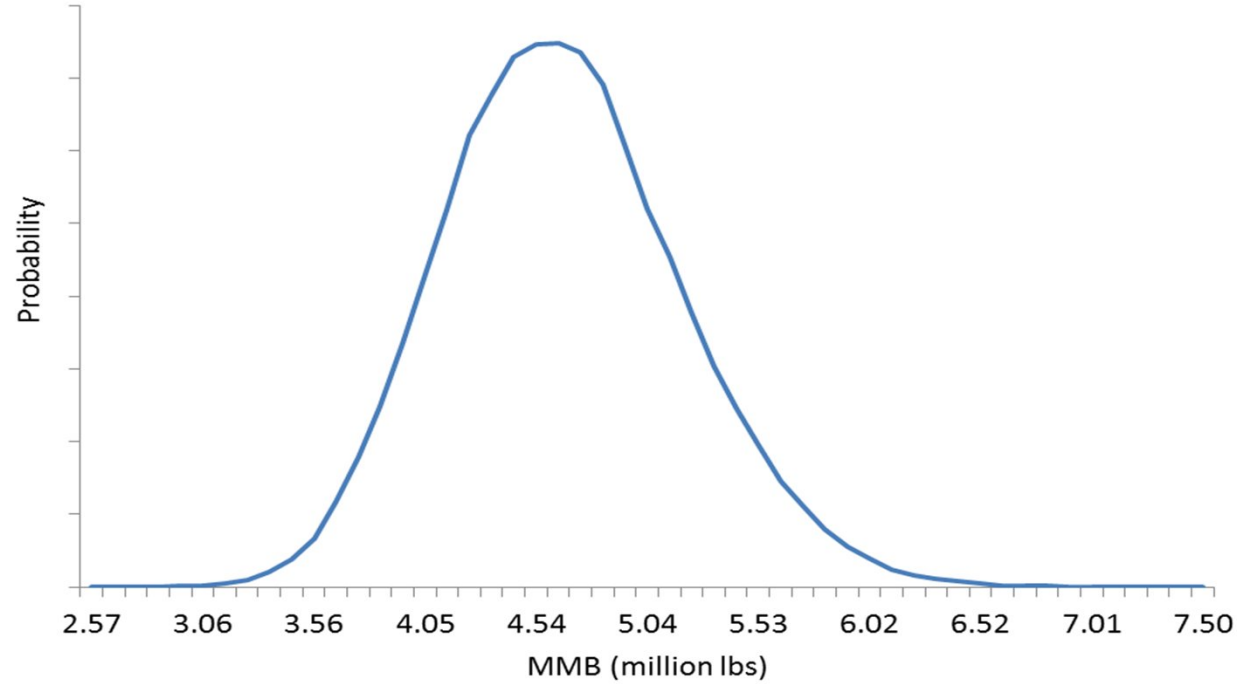
Comparison of Model Scenarios

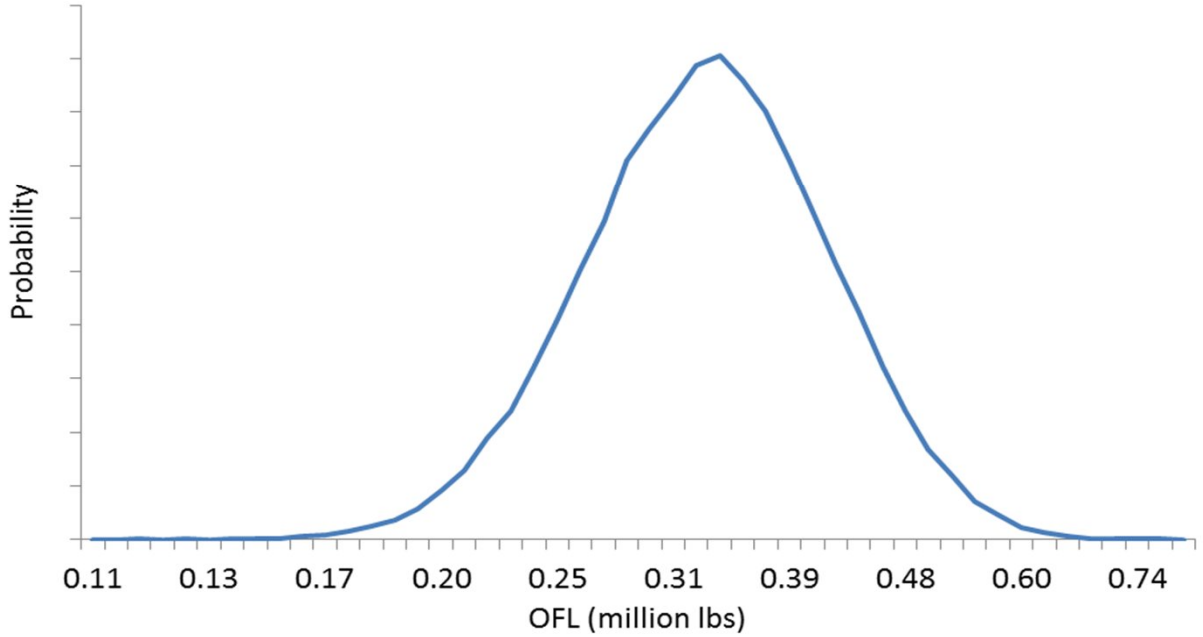
1. Scenarios T, 0, 00, 1:
   (1) no big differences of results,
   (2) strong temporal residual patterns for both survey and stage compo. Data.
2. Scenarios 2, 3: (with additional CV for pot survey)
   (1) strong temporal residual patterns for both survey and stage compo. Data,
   (2) an opposite trend of biomass vs the pot survey CPUE during recent years.
3. Scenarios 4 – 7: (either 2 molting proba. or selectivities for two periods)
   (1) Solving the problems of temporal residual patterns,
   (2) with an additional CV, scenarios 4-7 also down weight the pot survey data and result in biomass estimates quite different from the pot survey CPUE during recent years.
4. Scenario 9: fitting the pot survey data better than scenarios 4-7, but having similar problems with scenarios 4-7 with the additional CV.
5. Considering the problems with Scenarios T – 7 and 9, we would eliminate them for overfishing/overfished determination.

Comparison of Model Scenarios

6. Scenarios 8, 10: (without additional CV for pot survey)
   (1) Very good fit to the data,
   (2) If we believe the change in molting probability is acceptable, pick scen.8.
   (3) Scen. 10 fits the data statistically better than scen. 8, & if we think the change in trawl survey selectivities is reasonable, then pick scen. 10 over 8.
7. Scenarios 9-4, 9-0: Just used for comparison for station R-24 adjustment.
8. Scenarios 10-4, 10-3, 10-2 and 10-0: (without additional CV for pot survey)
   (1) Make more sense for the area-swept abundances during recent years,
   (2) Very good fit to the data, and the fits are better than scenario 10,
   (3) Scenario 10-4 seems a more reasonable adjustment to station R-24,
   (4) Suggest scenario 10-4 for overfishing/overfished determination in 2015.
9. Estimated trawl selectivities are a combination of selectivities and catchability. It is likely that trawl catchability is greater than 1 and the selectivities can be scaled to be 1 or less.

Scenario 10-4
2015





	OFL	ABC	Ret. catch	Pot male bycatch	Groundfish bycatch
Scen. 10 (1000t):	0.1560	0.1248	0.1495	0.0064	0.0001
(million lbs):	0.3440	0.2752	0.3296	0.0141	0.0003
Scen.10-4 (1000t):	0.1616	0.1292	0.1545	0.0069	0.0001
(million lbs):	0.3562	0.2849	0.3407	0.0152	0.0003

Status and catch specifications (1000 t) (scenario 10-4):

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2011/12	1.50	5.03	1.15	0.85	0.95	1.70	1.54
2012/13	1.80	2.85	0.74	0.73	0.82	1.02	0.92
2013/14	1.50	3.01	0	0	0.0003	0.56	0.45
2014/15	1.71	1.90	0.30	0.14	0.15	0.43	0.34
2015/16		1.80				0.16	0.13

Basis for the OFL: All table values are in 1000 t:

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
2011/12	3a	3.11	7.17	2.31	0.18	1989-2010	0.18
2012/13	3a	3.56	5.63	1.56	0.18	1978-2012	0.18
2013/14	3b	3.06	3.01	0.98	0.18	1978-2013	0.18
2014/15	3b	3.28	2.71	0.82	0.14	1978-2014	0.18
2015/16	3b	3.42	1.80	0.53	0.08	1978-2015	0.18

After Thoughts

1. Natural mortality may play a role for the high estimated survey catchability and selectivities:
   - if M is higher than we assumed, the selectivities/catchability would be overestimated.
   - M and selectivities/catchability are confounded and difficult to be estimated together.
2. For spatial aggregation distribution, a high or low estimated CV is the result of hitting or not hitting a high patch:
   - A high CV is deserved, but a low CV may not be merited. An extremely low CV does not only impact the biomass estimates, but also makes it difficult to fall into the confidence interval.
   - Difficult to estimate an additional CV for years of without hitting a high patch.

Thanks