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Stock Assessment Update of Summer Flounder for 2015

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STATE OF STOCK

This assessment of summer flounder (*Paralichthys dentatus*) is an update through 2014 of commercial and recreational fishery catch data, research survey indices of abundance, and the analyses of those data. The summer flounder stock was not overfished but overfishing was occurring in 2014 relative to the biological reference points from the 2013 Stock Assessment Workshop (SAW) 57 benchmark assessment (NEFSC 2013; Figures 1-4). Fishing mortality on the fully selected age 4 fish ranged between 0.793 and 1.776 during 1982-1996 then decreased from 0.867 in 1997 to 0.284 in 2007. Since 2007 the fishing mortality rate has increased to 0.359 in 2014, 16% above the 2013 SAW 57 F_{MSY} proxy = $F_{35\%}$ = 0.309 (Figures 1-3). The 90% confidence interval for F in 2014 was 0.274 to 0.435. Spawning stock biomass (SSB) decreased from 24,134 mt in 1982 to 5,394 mt in 1989 and then increased to peaks of 50,357 mt in 2003 and 47,499 mt in 2010. SSB was estimated to be 40,323 mt in 2014, 65% of the 2013 SAW 57 SSB_{MSY} proxy = $SSB_{35\%}$ = 62,394 mt, and 29% above the 2013 SAW 57 ½ SSB_{MSY} proxy = ½ $SSB_{35\%}$ = 31,197 mt (Figures 1-2, 4). The 90% confidence interval for SSB in 2014 was 35,486 to 49,918 mt. The average recruitment from 1982 to 2014 is 41 million fish at age 0. The 1983 and 1985 year classes are the largest in the assessment time series, at 75 and 62 million fish, while the 1988 year class is the smallest at only 10 million fish. After four below-average year classes in 2010-2013 (36, 20, 23, and 27 million fish), the 2014 year class is currently estimated to be average at 41 million fish (Figures 4-5).

No strong internal model retrospective patterns in F or SSB are evident in the updated assessment model, as the average retrospective errors over the last 7 terminal years are < 15% (Figures 6-7), comparable to the magnitude of the 2013 SAW 57 retrospective errors. The 2014 model estimates of F and SSB adjusted for this minor internal retrospective error are within the model estimate 90% confidence intervals (Figure 2). There is, however, evidence of a recent, consistent, small magnitude pattern in both the underestimation of F and the overestimation of SSB for the last 5 terminal years. There is a stronger and more consistent recent retrospective pattern in recruitment as 5 of the last 7 year classes have been initially over-estimated by a range of 22% to 49% (Figure 8). The historical assessment retrospective likewise indicates the emergence of a gradual upward adjustment of recent F estimates and downward adjustment of recent SSB estimates since the 2011 updated assessment (Figure 9). Tracking of recent assessment estimates and projections of Catch, F, and SSB indicates that while catches have not substantially exceeded the specified Acceptable Biological Catch (ABC; Figure 10), projected F has been exceeded and projected SSB has not been achieved (Figure 11-12). This result is mainly due to the recruitment to the stock of four below-average year classes in 2010-2013.

PROJECTIONS

If the total catch of summer flounder in 2015 equals the specified ABC = 10,329 mt = 22.772 million lbs, the median F in 2015 is projected to be 0.385, above the fishing mortality threshold = F_{MSY} proxy = $F_{35\%}$ = 0.309. The median SSB on November 1, 2015 is projected to be 42,423 mt = 93.527 million lbs, below the biomass target SSB_{MSY} proxy = $SSB_{35\%}$ = 62,394 mt = 137.555 million lbs.

If the stock is fished at the fishing mortality threshold = F_{MSY} proxy = $F_{35\%}$ = 0.309 in 2016-2018, the median annual total catches are the Overfishing Limit (OFL) for 2016-2018. The projected estimates in the following table are medians of the distributions for fixed F.

OFL Total Catch, Landings, Discards
Fishing Mortality (F) and Spawning Stock Biomass (SSB)
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2015	10,329	8,752	1,577	0.385	42,423
2016	8,194	6,807	1,387	0.309	45,198
2017	8,821	7,304	1,517	0.309	47,900
2018	9,365	8,028	1,337	0.309	50,496

CATCH

Reported 2014 landings in the commercial fishery were 5,134 mt = 11.319 million lbs, about 8% over the commercial quota (4,767 mt = 10.509 million lbs). Estimated 2014 landings in the recreational rod-and-reel fishery were 3,354 mt = 7.394 million lbs, about 6% above the recreational harvest limit (3,179 mt = 7.008 million lbs). Total commercial and recreational landings in 2014 were 8,488 = 18.713 million lbs and total commercial and recreational discard losses were 1,717 mt = 3.785 million lbs, for a total catch in 2014 of 10,205 mt = 22.498 million lbs (Figure 3).

Catch and Status Table: Summer flounder
(weights in 000s mt, recruitment in millions, arithmetic means)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Max[1]	Min[1]	Mean[1]
Commercial landings	7.7	6.3	4.5	4.1	4.8	6.1	7.5	5.9	5.7	5.1	17.1	4.0	7.5
Commercial discards[3]	1.5	1.5	2.1	1.2	1.4	1.5	1.1	0.7	0.7	0.8	2.2	0.2	1.1
Recreational landings	4.9	4.8	4.2	3.7	2.7	2.3	2.6	2.9	3.2	3.4	12.5	1.4	4.7
Recreational discards[3]	1.0	0.8	1.0	1.2	1.1	1.1	1.1	0.8	0.7	0.9	1.2	0.1	0.7
Total Catch	14.0	12.1	10.0	9.3	8.8	9.5	11.4	10.3	10.3	10.2	26.3	7.9	13.4
Commercial quota	8.2	6.4	4.7	4.3	5.0	6.0	8.0	5.8	5.4	4.8	8.1	8.2	6.9
Recreational harvest limit	5.5	4.3	3.1	2.9	3.3	4.0	5.3	3.9	3.5	3.2	5.5	2.9	4.6
Spawning Stock Biomass[2]	45.4	46.2	44.9	44.8	46.5	47.5	45.4	45.3	41.5	40.3	50.4	5.4	28.8
Recruitment (age 0)	29.5	36.8	38.2	45.2	53.4	36.4	20.3	22.5	27.3	41.4	75.2	9.6	41.8
F (age 4)	0.47	0.35	0.28	0.35	0.35	0.38	0.45	0.36	0.35	0.36	1.78	0.28	0.81

1: Over the period 1982-2014
2: On November 1 annually
3: Dead discards

STOCK DISTRIBUTION AND IDENTIFICATION

The Mid Atlantic Fisheries Management Council (MAFMC) and Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan for summer flounder defines the management unit as all summer flounder from the southern border of North Carolina northeast to the US-Canada border. For assessment purposes, the definition of Wilk et al. (1980) of a unit stock extending from Cape Hatteras north to New England has been accepted in this and previous assessments. The current management unit is consistent with a summer flounder genetics study, which revealed no population subdivision at Cape Hatteras (Jones and Quattro 1999). A consideration of summer flounder stock structure incorporating tagging data supported the existence of stocks north and south of Cape Hatteras, with the stock north of Cape Hatteras

possibly composed of two distinct spawning aggregations, off New Jersey and Virginia-North Carolina (Kraus and Musick 2003). The assessment is consistent with the conclusions of this study.

DATA AND ASSESSMENT

The population model implemented for summer flounder is the forward projecting age-structured model ASAP (Legault and Restrepo 1998; NFT 2013a). The model assumes age-dependent values for instantaneous natural mortality (M) that result in a mean value of M = 0.25. The catch in the model includes both commercial and recreational fishery landings and discards at age. The fishery landings and discards are treated as two fleets in the model. Indices of stock abundance including age compositions from the NEFSC winter, spring, and fall; Massachusetts spring and fall; Rhode Island fall and monthly fixed; Connecticut spring and fall; Delaware, New York, New Jersey, VIMS ChesMMAP, and VIMS NEAMAP spring and fall trawl surveys were used in the ASAP model calibration. Aggregate indices of stock abundance from the URI GSO trawl survey and NEFSC MARMAP and ECOMON larval surveys, and recruitment indices (age 0; Young-Of-the-Year, YOY) from surveys conducted by the states of Massachusetts, Delaware, Maryland, and Virginia were also used in the model calibration.

All of the ongoing research survey indices (expressed as aggregate N) have declined since their most recent peak (generally in 2009-2012) to 2014, in percent as follows:

NEFSC Spring -49%
NEFSC Fall -27%
MADMF Spring -57%
MADMF Fall -43%
RIDFW Fall -64%
RIDFW Monthly -82%
URIGSO -67%
CTDEEP Spring -22%
CTDEEP Fall -54%
NYDEC -28%
NJDFW -40%
DEDFW -17%
VIMS ChesMMAP -98%
NEAMAP Spring -51%
NEAMAP Fall -60%

Most of the YOY indices suggest good recruitment in 2002, 2004, and 2009, and poorer recruitment since then.

No strong internal model retrospective patterns in F or SSB are evident in the updated assessment model, as the average retrospective errors over the last 7 terminal years are < 15% (Figures 6-7), comparable to the magnitude of the 2013 SAW 57 retrospective errors. The 2014 model estimates of F and SSB adjusted for this minor internal retrospective error are within the model estimate 90% confidence intervals (Figure 2). There is, however, evidence of a recent, consistent, small-magnitude pattern in both the underestimation of F and the overestimation of SSB for the last 5 terminal years. There is a stronger and more consistent recent retrospective pattern in recruitment as 5 of the last 7 year classes have been initially over-estimated by a range of 22% to 49% (Figure 8). The historical assessment retrospective likewise indicates the

emergence of a gradual upward adjustment of recent F estimates and downward adjustment of recent SSB estimates since the 2011 updated assessment (Figure 9). Tracking of recent assessment estimates and projections of Catch, F, and SSB indicates that while catches have not substantially exceeded the specified ABCs (Figure 10), projected F has been exceeded and projected SSB has not been achieved (Figure 11-12). This result is mainly due to the recruitment to the stock of 4 below average year classes in 2010-2013.

BIOLOGICAL REFERENCE POINTS (BRPS)

The existing 2013 SAW 57 biological reference points for summer flounder are based on stochastic yield and SSB per recruit and stochastic projection models in the NOAA NFT framework (NFT 2013b, c; Thompson and Bell 1934) using values from the 2013 assessment. The fishing mortality reference point is $F_{35\%}$ = 0.309 (CV = 15%) as a proxy for F_{MSY}. The biomass reference point proxy is estimated as the projection of January 1, 2013 stock sizes at $F_{35\%}$ = 0.309 and mean recruitment of 43 million fish per year (1982-2012). The SSB_{MSY} proxy is estimated to be 62,394 mt (137.6 million lbs; CV = 13%), and the biomass threshold of one-half SSB_{MSY} is estimated to be 31,197 mt (68.8 million lbs; CV = 13%). The MSY proxy is estimated to be 12,945 mt (28.539 million lbs; CV = 13%; 10,455 mt = 23.049 million lbs of landings plus 2,490 mt = 5.490 million lbs of discards).

FISHING MORTALITY

Fishing mortality on the fully selected age 4 fish ranged between 0.793 and 1.776 during 1982-1996 then decreased from 0.867 in 1997 to 0.284 in 2007. Since 2007 the fishing mortality rate has increased to 0.359 in 2014, 16% above the 2013 SAW 57 F_{MSY} proxy = $F_{35\%}$ = 0.309 (Figures 1-3). The 90% confidence interval for F in 2014 was 0.274 to 0.435.

SPAWNING STOCK BIOMASS

Spawning stock biomass (SSB) decreased from 24,134 mt in 1982 to 5,394 mt in 1989 and then increased to peaks of 50,357 mt in 2003 and 47,499 mt in 2010. SSB was estimated to be 40,323 mt in 2014, 65% of the 2013 SAW 57 SSB_{MSY} proxy = $SSB_{35\%}$ = 62,394 mt, and 29% above the 2013 SAW 57 ½ SSB_{MSY} proxy = ½ $SSB_{35\%}$ = 31,197 mt (Figures 1-2 & 4). The 90% confidence interval for SSB in 2014 was 35,486 to 49,918 mt.

RECRUITMENT

The average recruitment from 1982 to 2014 is 41 million fish at age 0. The 1983 and 1985 year classes are the largest in the assessment time series, at 75 and 62 million fish, while the 1988 year class is the smallest at only 10 million fish. After 4 below average year classes in 2010-2013 (36, 20, 23, and 27 million fish), the 2014 year class is currently estimated to be average at 41 million fish (Figures 4-5).

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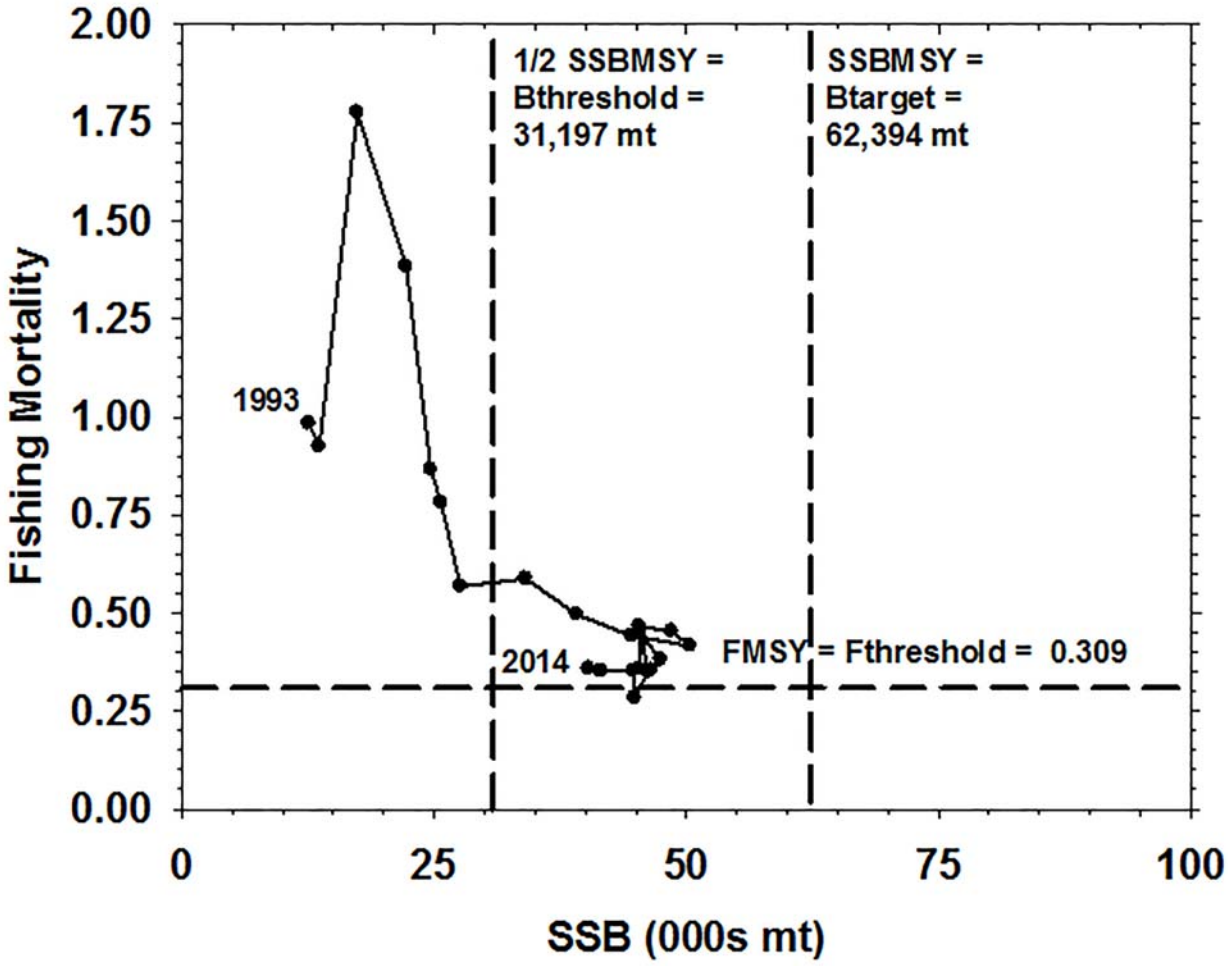

Figure 1. Stock status time series since 1993 for summer flounder. The horizontal dashed line is the 2013 Stock Assessment Workshop (SAW) 57 fishing mortality threshold reference point proxy; the vertical dashed lines are the 2013 SAW 57 biomass threshold and target reference point proxies.

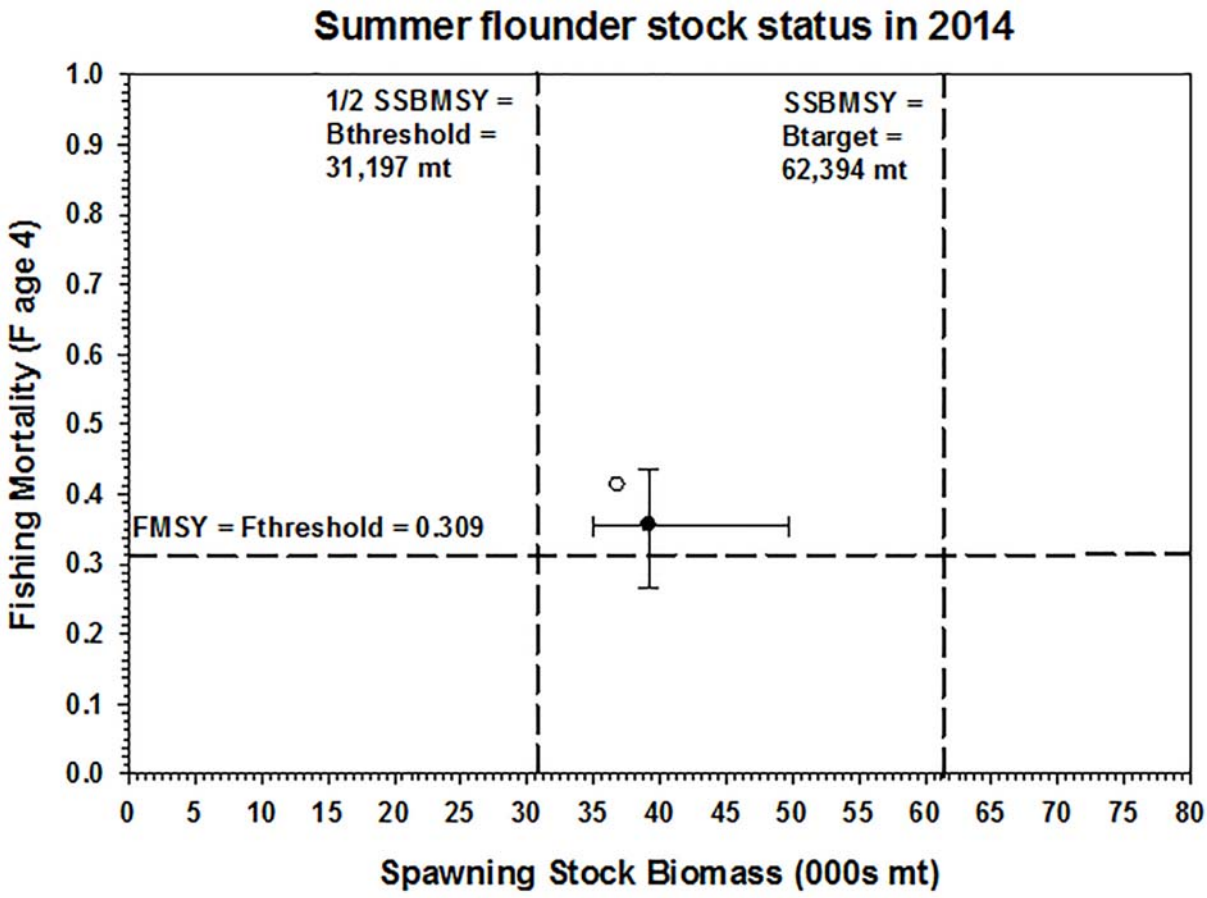

Figure 2. Stock status of summer flounder in 2014 with respect to 2013 Stock Assessment Workshop (SAW) 57 threshold and target reference point proxies. The filled circle is the model estimate and the error bars are 90% confidence intervals; the open circle is the model estimate adjusted for internal model retrospective error.

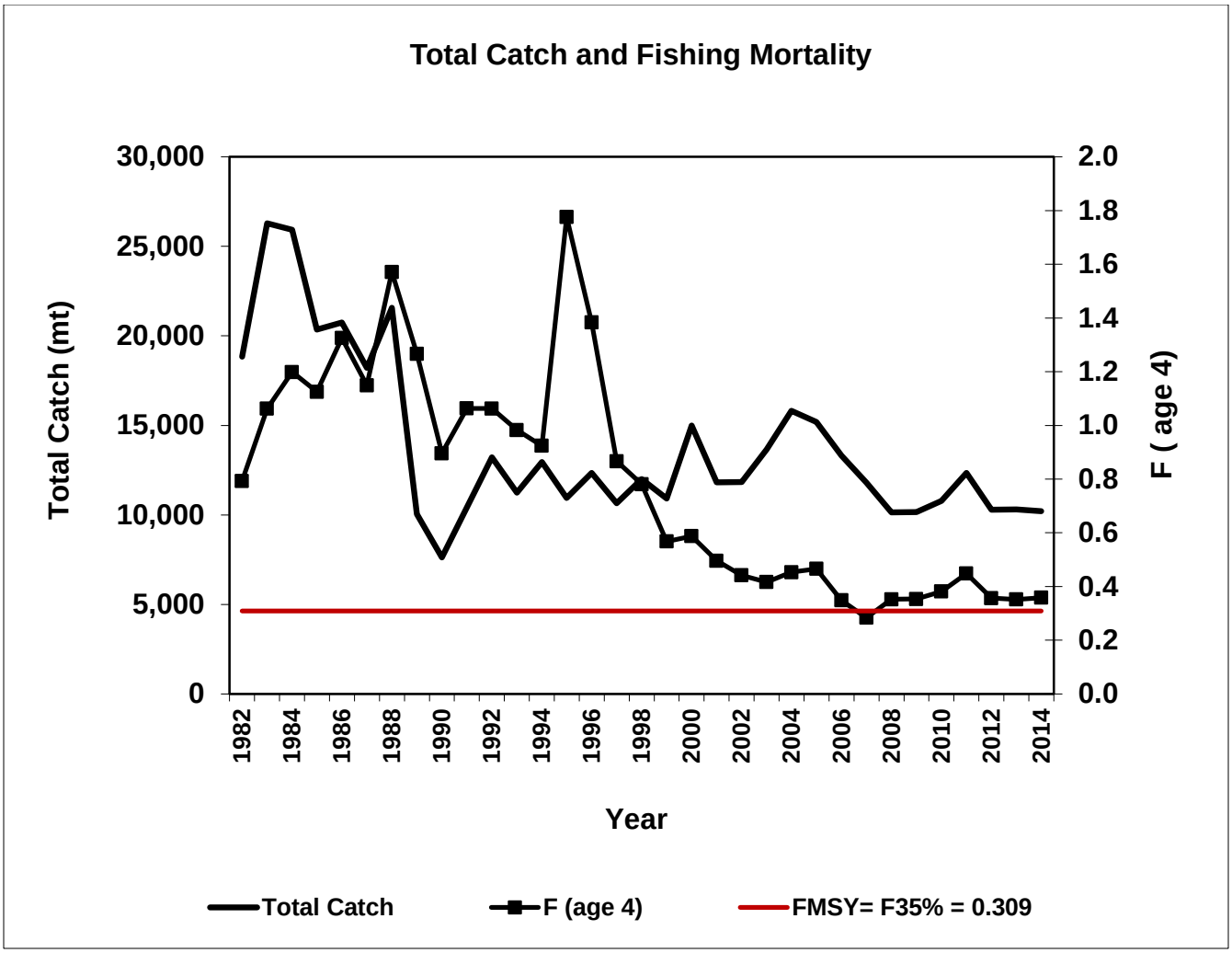

Figure 3. Total fishery catch and fully-recruited fishing mortality (F, peak at age 4) of summer flounder. The horizontal red line is the 2013 Stock Assessment Workshop (SAW) 57 fishing mortality threshold reference point proxy.

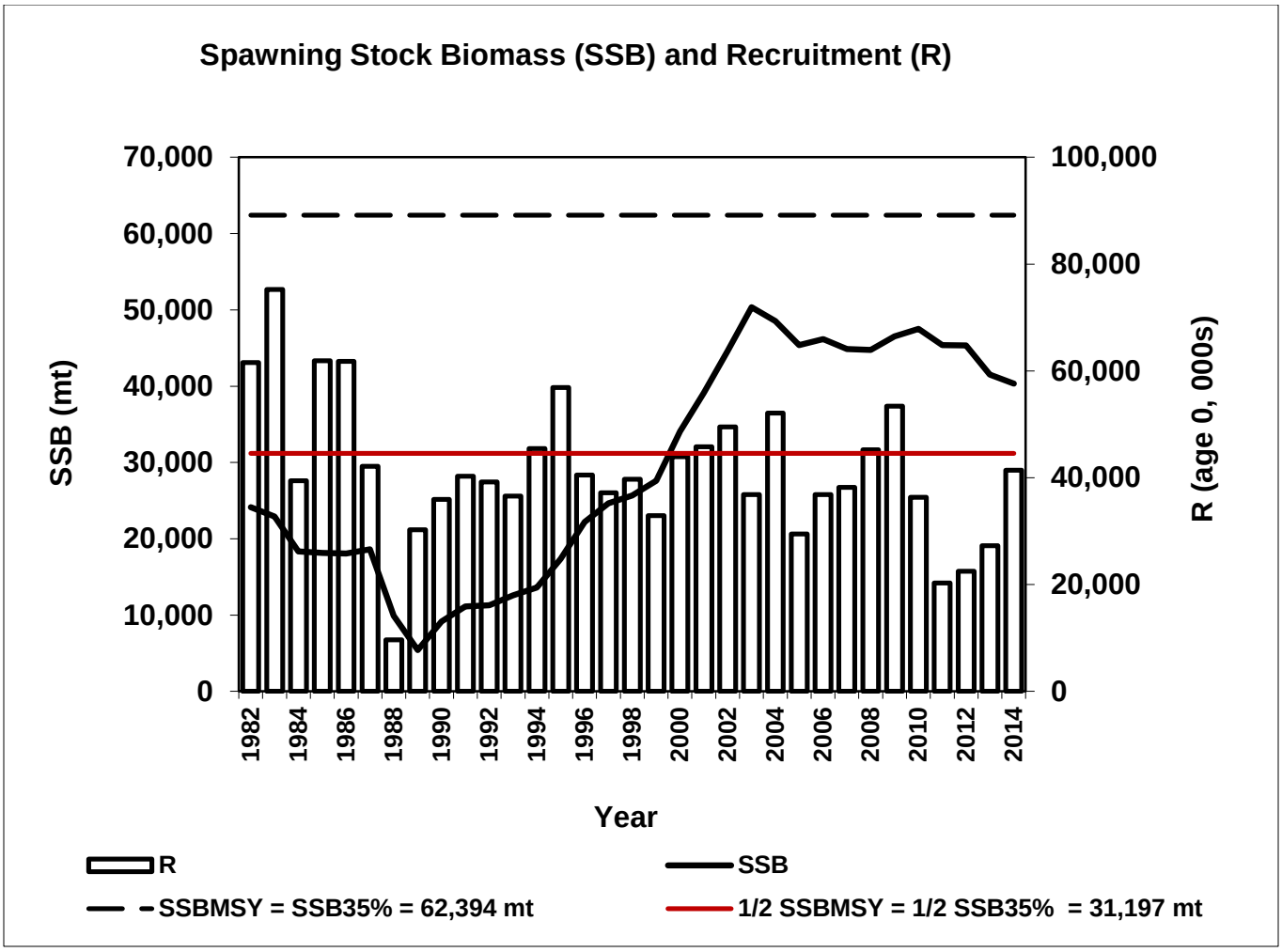

Figure 4. Summer flounder spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year. The horizontal dashed line is the 2013 Stock Assessment Workshop (SAW) 57 biomass target reference point proxy; the horizontal red line is the biomass threshold reference point proxy.

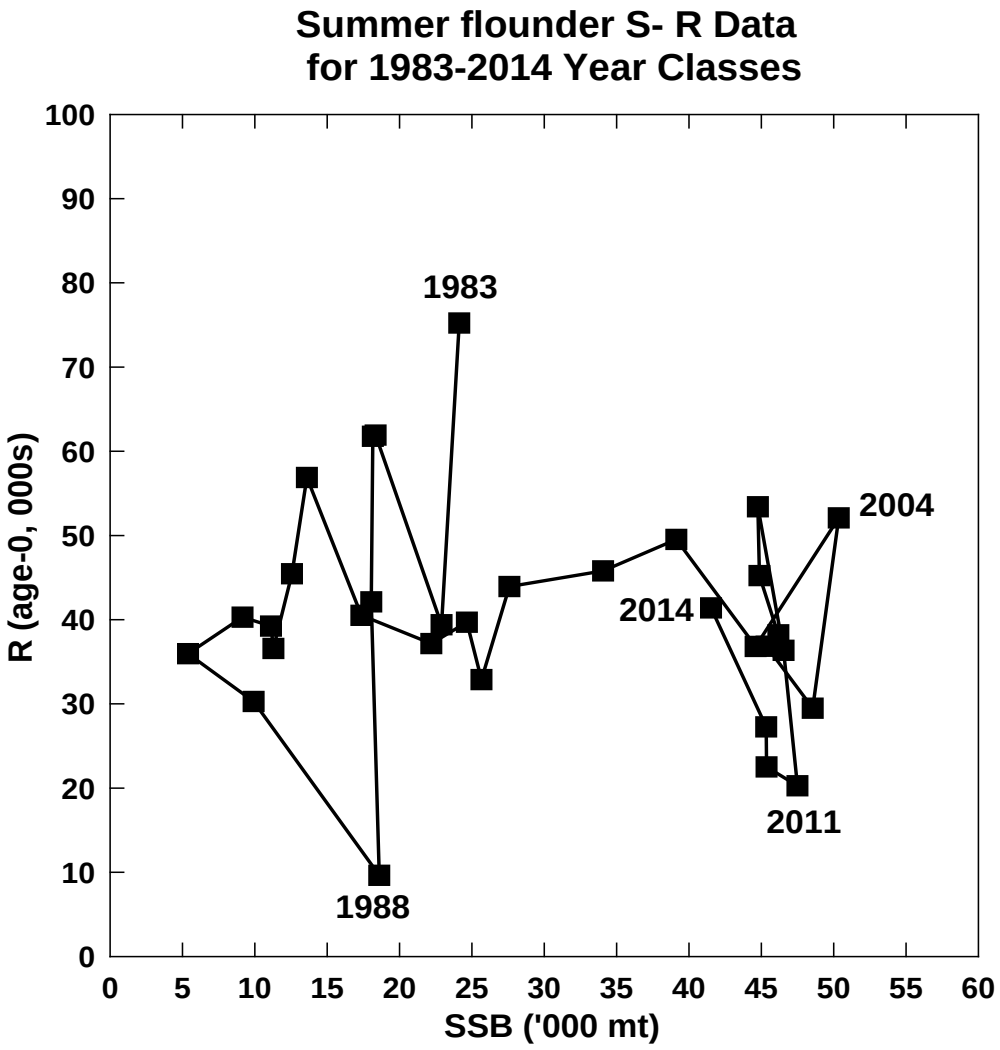

Figure 5. Stock-recruitment scatter plot for summer flounder 1983-2014 year classes.

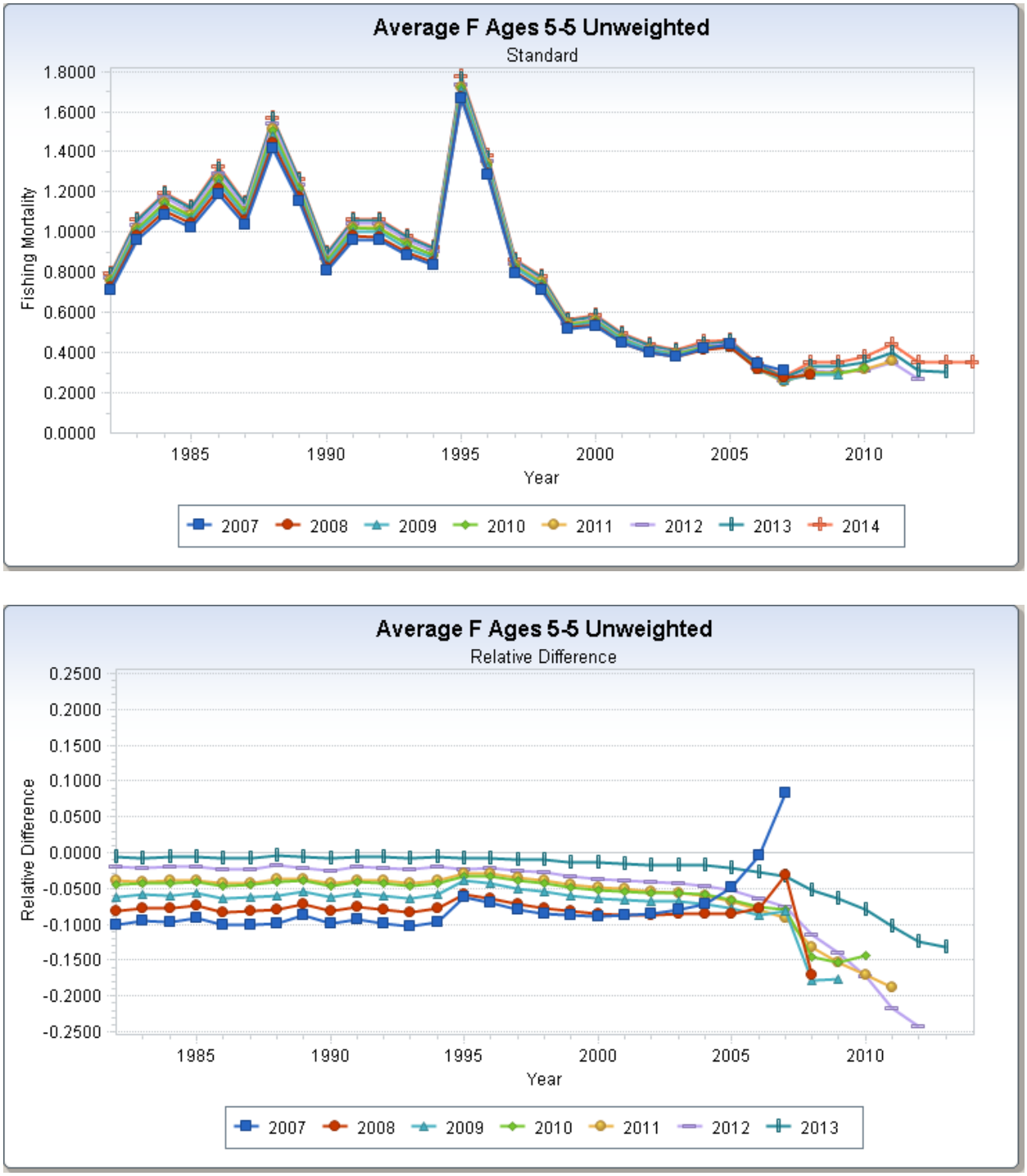

Figure 6. Results of internal model retrospective analysis for summer flounder: fully recruited F (true age 4, model age 5); average retrospective error = -14%.

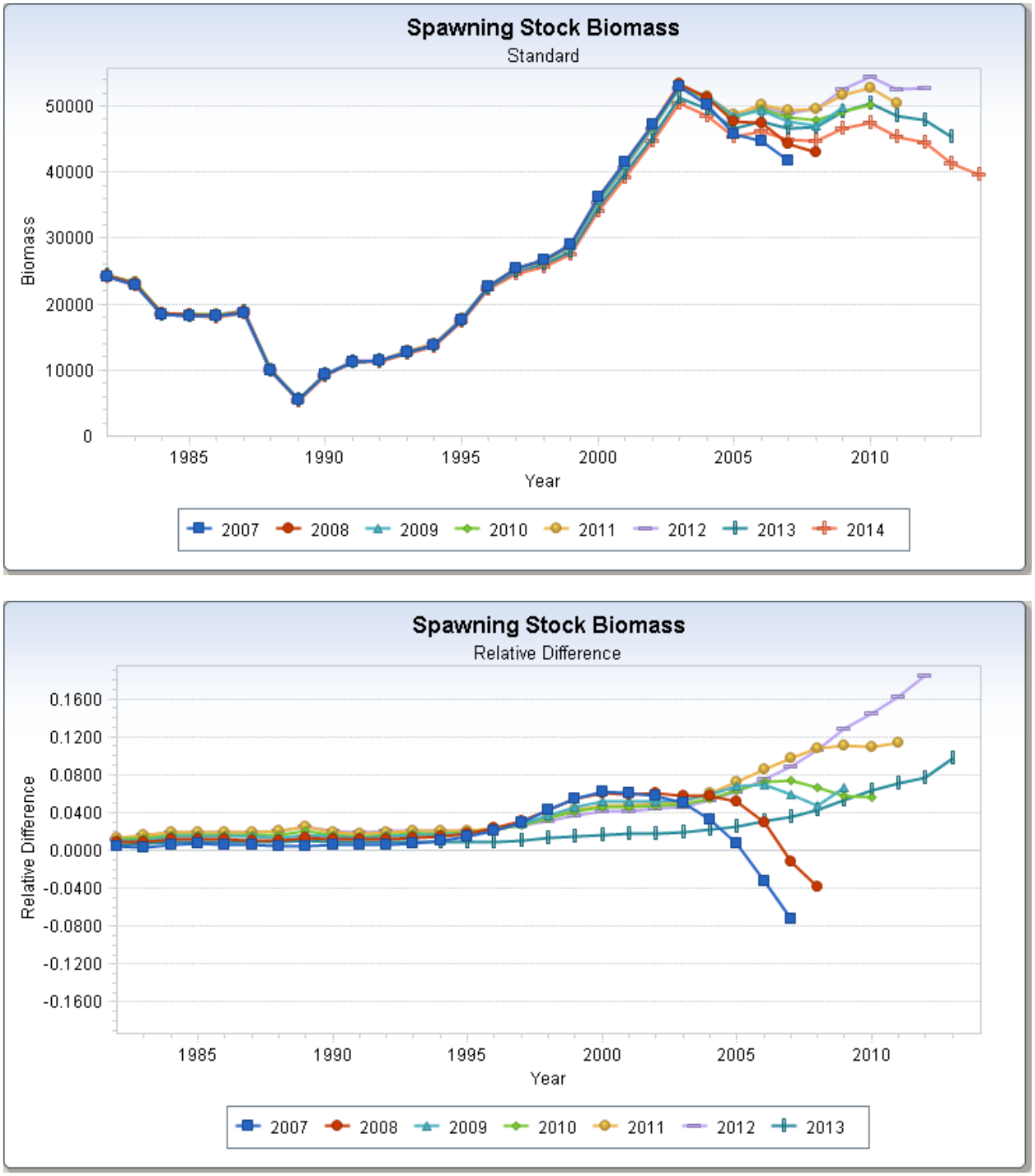

Figure 7. Results of internal model retrospective analysis for summer flounder: Spawning Stock Biomass; average retrospective error = +6%.

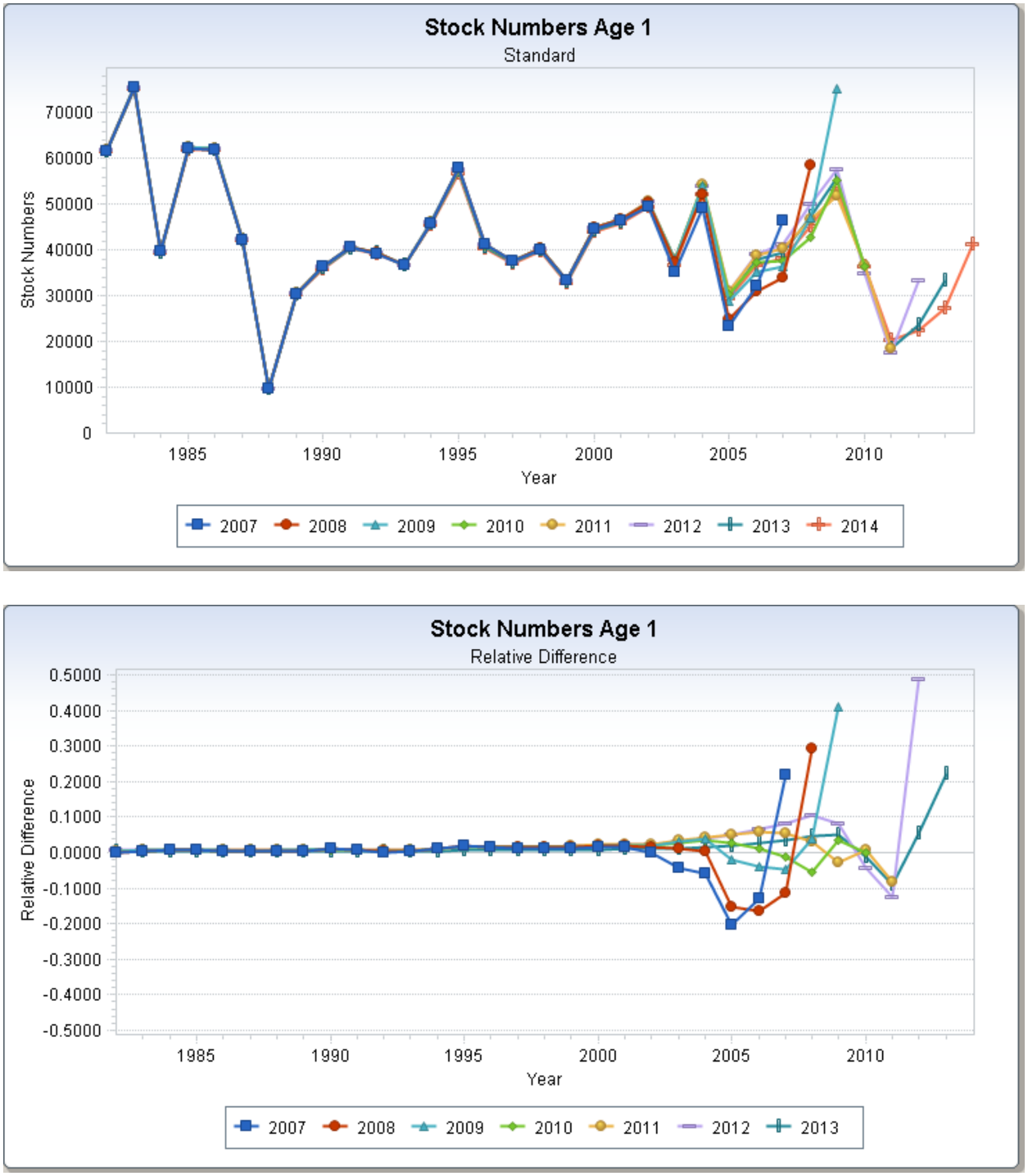

Figure 8. Results of internal model retrospective analysis for summer flounder: R (recruitment at true age 0, model age 1); average retrospective error = +22%.

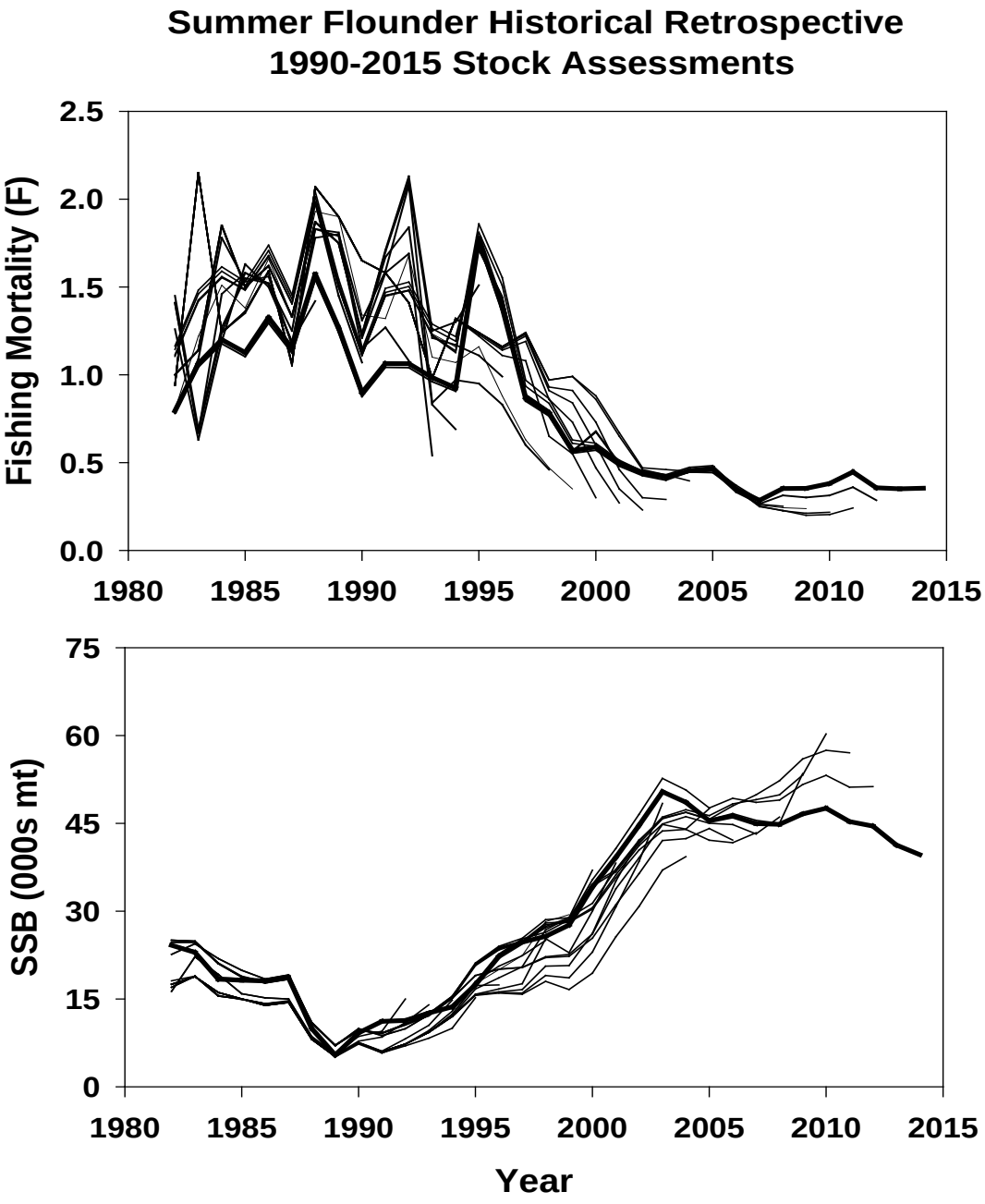

Figure 9. Comparison of estimates from the 1990-2015 summer flounder assessments.

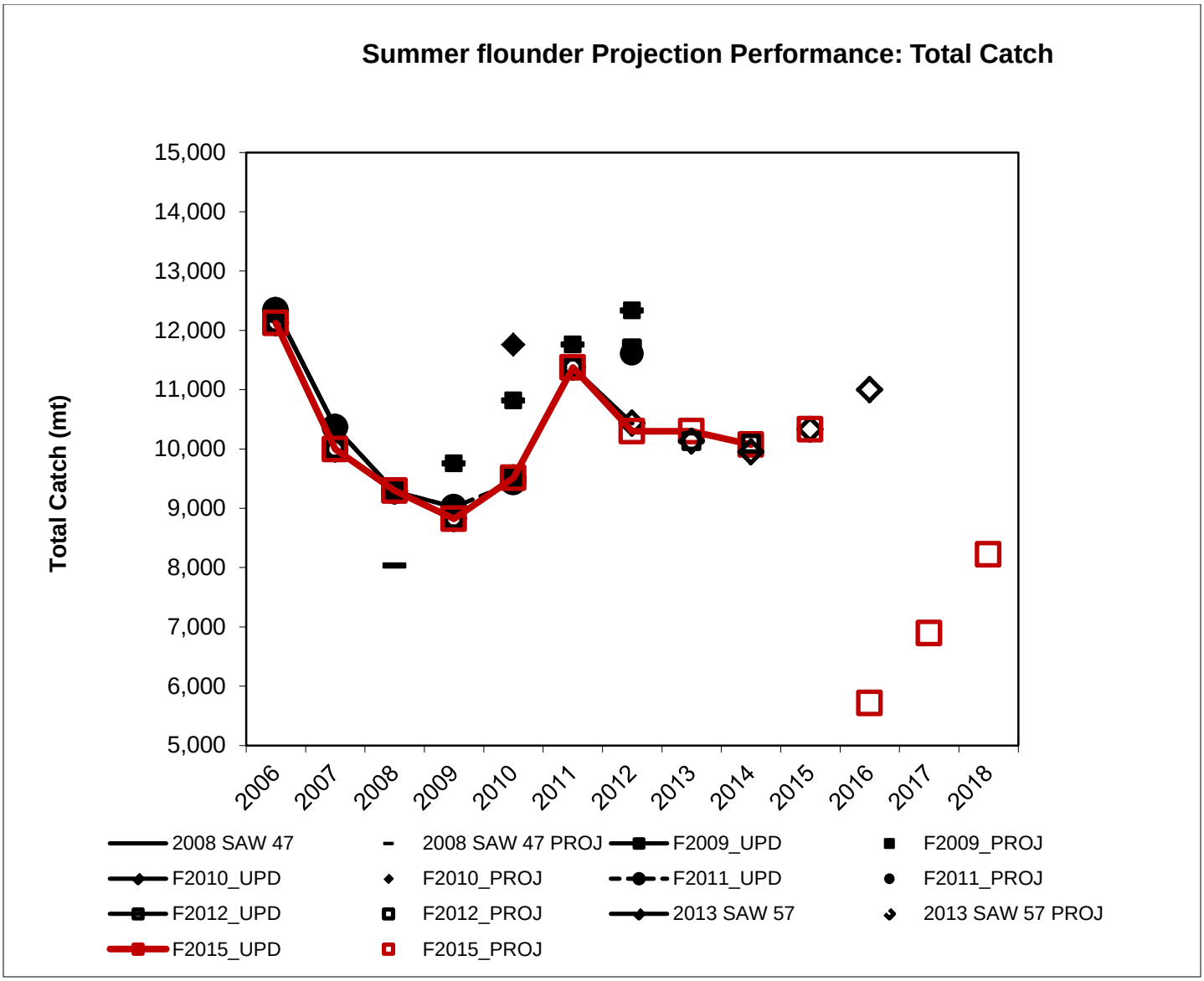

Figure 10. Comparison of estimated and projected catch (ABC) from the 2008 through 2015 summer flounder assessments. The F2015 assessment catches projected for 2016-2018 are the ABCs.

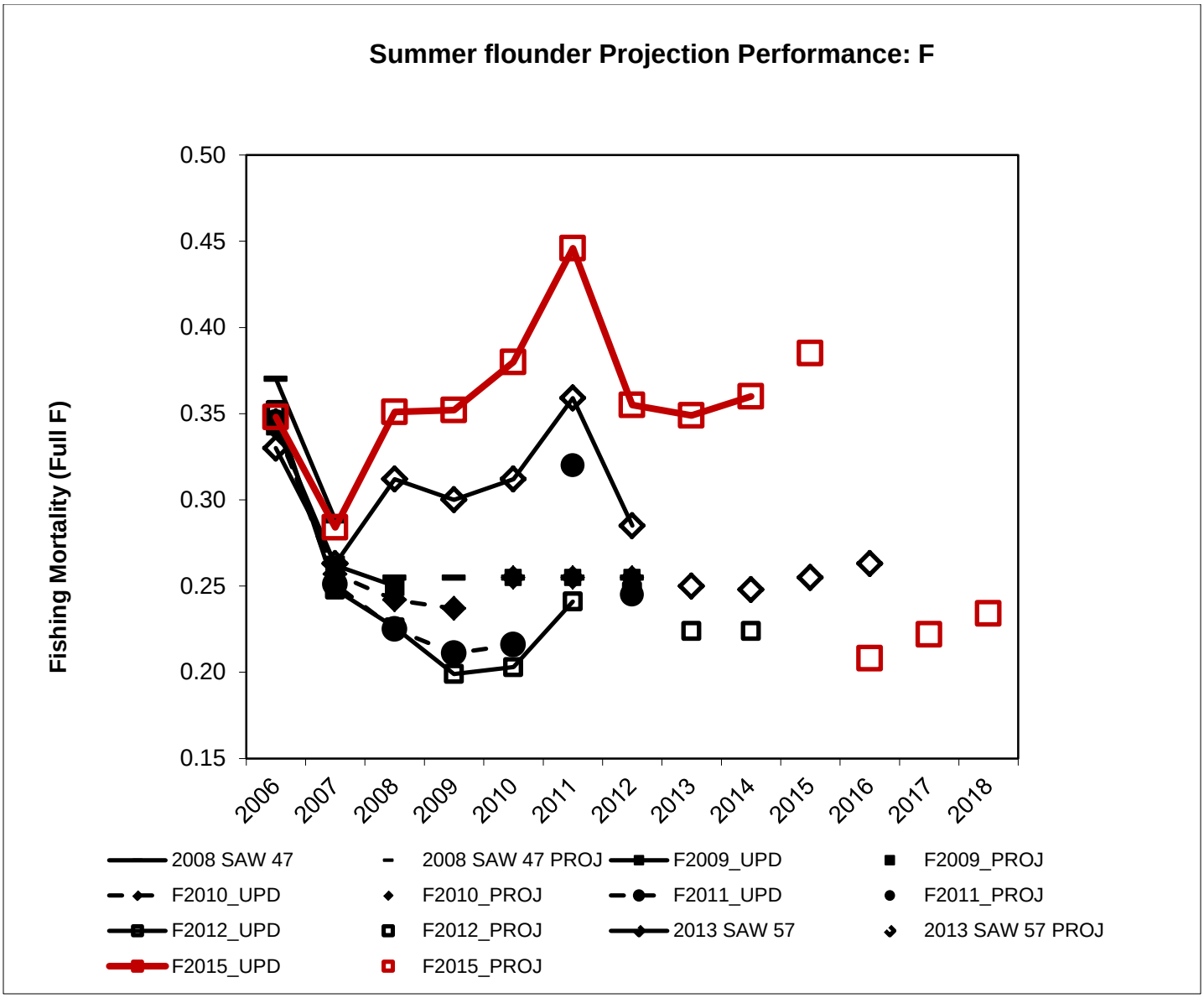

Figure 11. Comparison of estimated and projected fishing mortality (F, peak age 4) from the 2008 through 2015 summer flounder assessments. The F2015 assessment F projected for 2016-2018 corresponds to the projected ABCs.

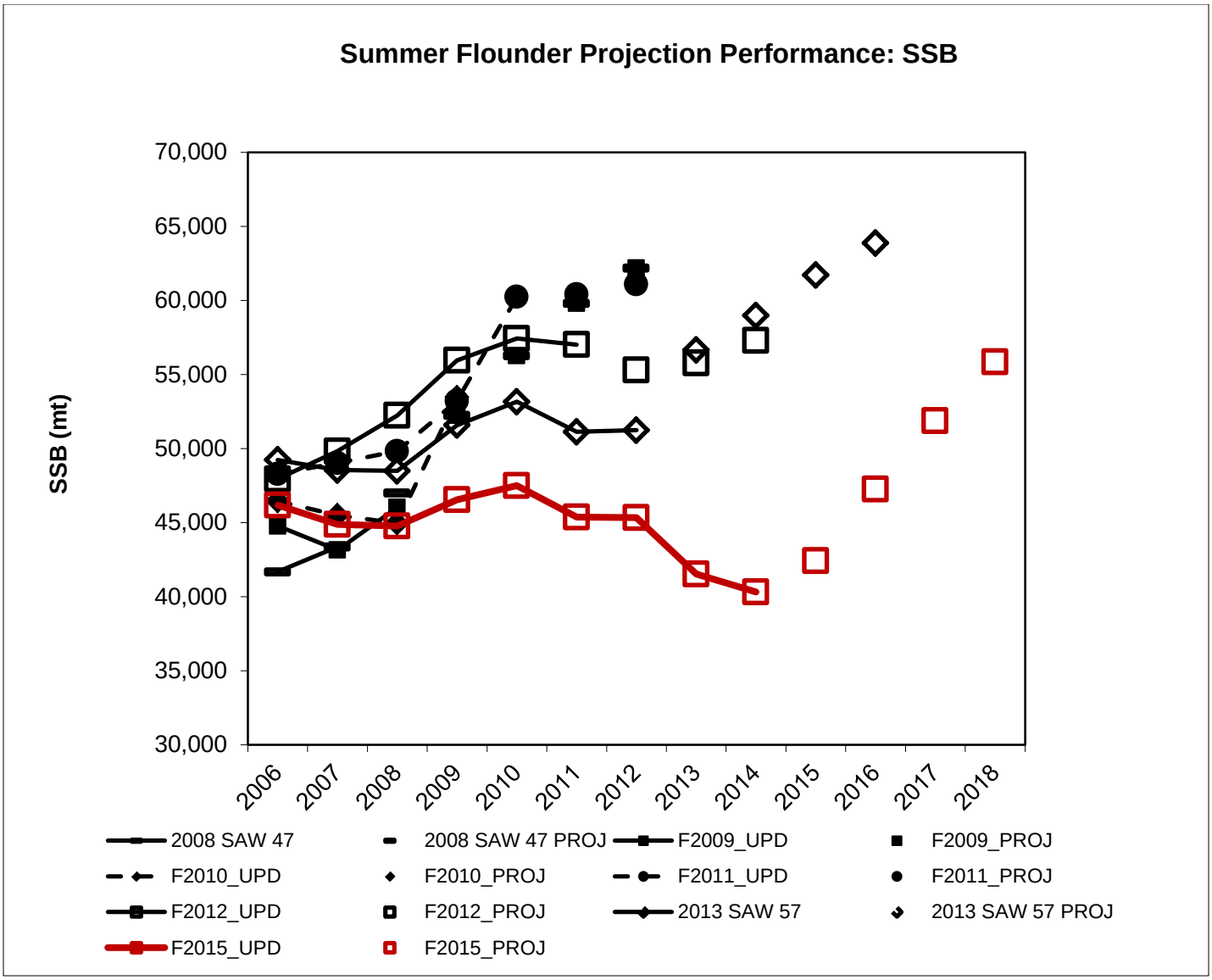

Figure 12. Comparison of estimated and projected Spawning Stock Biomass (SSB) from the 2008 through 2015 summer flounder assessments. The F2015 assessment SSB projected for 2016-2018 corresponds to the projected ABCs.

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