A. SUMMER FLOUNDER ASSESSMENT SUMMARY FOR 2013

State of Stock: The summer flounder stock was not overfished and overfishing was not occurring in 2012 relative to the new (updated) biological reference points from the 2013 SAW/SARC57 (Figure A1). Fishing mortality on the fully selected age 4 fish ranged between 0.790 and 1.745 during 1982-1996. The fishing mortality rate has decreased from 0.849 in 1997 to 0.285 in 2012, below the new reference point F_{MSY} proxy = $F_{35\%}$ = 0.309 (Figure A2). There is a 90% probability that the fishing mortality rate in 2012 was between 0.213 and 0.343. Spawning stock biomass (SSB) decreased from 24,300 mt in 1982 to 5,521 mt in 1989, and then increased to a peak of 53,156 mt by 2010. SSB was estimated to be 51,238 mt in 2012, about 82% of the new reference point SSB_{MSY} proxy = $SSB_{35\%}$ = 62,394 mt (Figure A3). There is a 90% chance that SSB in 2012 was between 45,781 and 61,297 mt. The average recruitment from 1982 to 2012 is 43 million fish at age 0. The 1982 and 1983 year classes are the largest in the assessment time series, at 62 and 76 million fish; the 1988 year class is the smallest at only 10 million fish. The 2012 year class is currently estimated to be about 37 million fish (Figure A4).

Projections: If the 2013 Annual Catch Limit (ACL) of 10,133 mt = 22.339 million lbs is taken, and the 2013 median (50% probability) projected dead discards are 1,735 mt = 3.825 million lbs, then the median landings are projected to be 8,398 mt = 18.514 million lbs. The median F in 2013 is projected to be 0.250, below the new fishing mortality threshold = F_{MSY} proxy = $F_{35\%}$ = 0.309. The median SSB on November 1, 2013 is projected to be 56,662 mt = 124.918 million lbs, below the new biomass target SSB_{MSY} proxy = $SSB_{35\%}$ = 62,394 mt = 137.555 million lbs.

If the stock is fished at the new fishing mortality threshold = F_{MSY} proxy = $F_{35\%}$ = 0.309 in 2014, the median landings are projected to be 9,961 mt = 21.960 million lbs, with median dead discards of 2,177 mt = 4.799 million lbs, and median total catch = 12,138 mt = 26.760 million lbs. This projected median total catch would be the Overfishing Limit (OFL) for 2014, and is less than the new MSY proxy = 12,945 mt (28.539 million lbs; 10,455 mt = 23.049 million lbs of median landings plus 2,490 mt = 5.490 million lbs of median dead discards). The median SSB on November 1, 2014 is projected to be 57,140 mt = 125.972 million lbs, 92% of the new biomass target of SSB_{MSY} proxy = $SSB_{35\%}$ = 62,394 mt = 137.555 million lbs. The projected catch estimates in the following table are medians of the catch distributions for fixed F in 2014-2016.

OFL Total Catch, Landings, Discards, Fishing Mortality (F)
and Spawning Stock Biomass (SSB) in 2014-2016
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2014	12,138	9,961	2,177	0.309	57,140
2015	11,785	9,497	2,288	0.309	58,231
2016	11,914	9,527	2,387	0.309	59,268

If the MAFMC risk policy is applied by the SSC and this assessment is classified as "typical level 3", then given the size of SSB relative to SSB_{MSY} and assuming OFL CV = 100% and an annual OFL corresponding to F = 0.309, then results associated with Acceptable Biological Catch (ABC) follow:

ABC Total Catch, Landings, Discards, Fishing Mortality (F)
and Spawning Stock Biomass (SSB) in 2014-2016
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2014	8,071	6,649	1,422	0.197	60,581
2015	9,992	8,117	1,875	0.237	63,969
2016	10,729	8,681	2,048	0.245	66,469

Catch: Total landings peaked in 1983 at 26,100 mt = 57.540 million lbs. During the late 1980s and into 1990, landings decreased, reaching 4,200 mt = 9.259 million lbs in the commercial fishery in 1990 and 1,400 mt = 3.086 million lbs in the recreational fishery in 1989. Total landings were only 6,500 mt = 14.330 million lbs in 1990. Reported 2012 landings in the commercial fishery were 6,047 mt = 13.331 million lbs, about 5% over the commercial quota. Estimated 2012 landings in the recreational fishery (as estimated by the MRIP) were 2,853 mt = 6.290 million lbs, about 26% under the recreational harvest limit. Total commercial and recreational landings in 2012 were 8,900 mt = 19.621 million lbs and total commercial and recreational dead discards were 1,533 mt = 3.380 million lbs, for a total catch in 2012 of 10,433 mt = 23.001 million lbs. Commercial landings have accounted for 54% of the total catch since 1982, with recreational landings accounting for 34%, commercial discards about 8%, and recreational discards about 5%. Commercial discard losses in the otter trawl and scallop dredge fisheries have accounted for about 14% of the total commercial catch, assuming a commercial discard mortality rate of 80%. Recreational discard losses have accounted for about 12% of the total recreational catch, assuming a recreational discard mortality rate of 10%.

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

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Max[1]	Min[1]	Mean[1]
Commercial landings	6.5	8.2	7.8	6.3	4.5	4.1	4.8	5.9	7.5	6.0	17.1	4.0	7.7
Commercial discards[3]	1.1	1.6	1.5	1.5	2.1	1.2	1.4	1.5	1.1	0.7	2.2	0.2	1.2
Recreational landings	5.2	5.0	4.9	4.8	4.2	3.7	2.7	2.3	2.6	2.9	12.5	1.4	4.8
Recreational discards[3]	0.8	1.0	1.0	0.8	1.0	1.2	1.1	1.1	1.1	0.8	1.2	0.1	0.7
Total Catch	13.0	14.5	13.9	12.1	10.0	9.3	8.8	9.5	11.4	10.4	26.3	7.9	13.6
Commercial quota	6.3	7.7	8.2	6.4	4.7	4.3	5.0	6.0	8.0	5.8	8.1	8.2	7.1
Recreational harvest limit	4.2	5.1	5.5	4.3	3.1	2.9	3.3	4.0	5.3	3.9	5.5	2.9	4.7
Spawning Stock Biomass[2]	52.6	50.7	47.6	49.2	48.5	48.9	51.6	53.2	51.1	51.2	53.2	5.5	30.4
Recruitment (age 0)	37.8	53.5	32.3	39.0	40.0	48.7	54.9	34.6	19.6	37.2	75.8	9.8	43.0
F (age 4)	0.40	0.45	0.45	0.33	0.26	0.31	0.30	0.31	0.36	0.29	1.75	0.26	0.79

1: Over the period 1982-2012
2: On November 1 annually
3: Dead discards

Stock Distribution and Identification: The Mid-Atlantic Fishery 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 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.

Biological Reference Points (BRPs): The SAW/SARC57 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 new fishing mortality reference point is $F_{35\%}$ = 0.309 (CV = 15%) as a proxy for F_{MSY}. The new biomass reference point proxy is estimated as the projection of Jan 1, 2013 stock sizes at $F_{35\%}$ = 0.309 and mean recruitment of 43 million fish per year (1982-2012). The new SSB_{MSY} proxy is estimated to be 62,394 mt (137.6 million lbs; CV = 13%), and the new biomass threshold of one-half SSB_{MSY} is estimated to be 31,197 mt (68.8 million lbs; CV = 13%). The new 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).

The biological reference points estimated in the 2008 SAW47 assessment were MSY proxy = $F_{35\%}$ = 0.310, SSB_{MSY} proxy = $SSB_{35\%}$ = 60,074 mt, and MSY proxy = $MSY_{35\%}$ = 13,122 mt (NEFSC 2008). NMFS determined the summer flounder stock to be rebuilt in 2010, based on the 2011 assessment update (Terceiro 2011). The summer flounder stock is not overfished and overfishing is not occurring in 2012 relative to the SAW47 biological reference points.

Fishing Mortality: Fishing mortality calculated at the currently fully recruited (peak) age 4 ranged between 0.790 and 1.745 during 1982-1996. The fishing mortality rate has decreased from 0.849 in 1997 to 0.285 in 2012. There is a 90% probability that the fishing mortality rate in 2012 was between 0.213 and 0.343.

Spawning Stock Biomass: SSB decreased from 24,300 mt in 1982 to 5,521 mt in 1989, and then increased to a peak of 53,156 mt by 2010. SSB was estimated to be 51,238 mt in 2012, about 82% of the reference point SSB_{MSY} = $SSB_{35\%}$ = 62,394 mt. There is a 90% probability that SSB in 2012 was between 45,781 and 61,297 mt.

Recruitment: The average recruitment from 1982 to 2012 is 43 million fish at age 0. The 1982 and 1983 year classes are the largest in the assessment time series, at 62 and 76 million fish; the 1988 year class is the smallest at only 10 million fish. The 2012 year class is currently estimated to be about 37 million fish.

Special Comments: The benchmark 2008 SAW 47 assessment (NEFSC 2008) was updated annually through 2012 (Terceiro 2012). The summer flounder stock assessment has historically exhibited a consistent retrospective pattern of underestimation of F and overestimation of SSB; the causes of this previous pattern have not been determined. In the current assessment model, however, no persistent retrospective patterns are evident. Over the last 7 years, the annual retrospective change in fishing mortality has ranged from +22% in 2006 to -5% in 2009, the annual retrospective change in SSB has ranged from -2% in 2011 to -21% 2006, and the annual retrospective change in recruitment has ranged from -45 in 2005 to +33% in 2009. The historical retrospective indicates that general trends of fishing mortality, stock biomass, and recruitment have been consistent since the 1990s assessments (Figure A5).

The SAW/SARC57 assessment includes several new research survey time series. The URI GSO trawl, NY trawl, VIMS ChesMMAP trawl, VIMS NEAMAP spring and fall trawl, and the NEFSC MARMAP and ECOMON larval surveys are now tabulated in the assessment and used in the population model calibration.

The NEFSC research surveys and Partnership for Mid-Atlantic Fisheries Science (PMAFS) fishery sampling confirm sexually dimorphic, temporal, and spatial differences in growth of summer flounder. The SAW57 working group investigated these differences in sex and how it might affect the assessment, but it was not possible to develop a full sex-disaggregated analysis. Sex-specific differences in life history parameters and in the spatial distribution of summer flounder by size may have an effect on the assessment model results and the biological reference point calculations. The assessment model presented to the SARC was deemed to provide an acceptable evaluation of stock status. Among potential approaches, simulation studies could be used to identify the critical data and model components and indicate directions for future work.

The northward shift in the center of biomass for summer flounder may be due in part to the expansion in population age structure and increases in abundance. Environmental or other factors that may have influence on this shift have not been fully quantified.

References:

Jones WJ, Quattro JM. 1999. Genetic structure of summer flounder (*Paralichthys dentatus*) populations north and south of Cape Hatteras. Marine Biology 133: 129-135.

Kraus RT, Musick JA. 2003. A brief interpretation of summer flounder, *Paralichthys dentatus*, movements and stock structure with new tagging data on juveniles. Mar. Fish. Rev. 63(3): 1-6.

Legault CM, Restrepo VR. 1998. A flexible forward age-structured assessment program. ICCAT.Col. Vol. Sci. Pap. 49:246-253.

Northeast Fisheries Science Center (NEFSC) 2008. 47th Northeast Regional Stock Assessment Workshop (47th SAW) Assessment Report. US Dept Commerce, Northeast Fish Sci Cent Ref Doc. 08-12a, 335 p.

NOAA Fisheries Toolbox (NFT) 2013a. Age Structured Assessment Program (ASAP) version 3.0.11. (Internet address: http://nft.nefsc.noaa.gov).

NOAA Fisheries Toolbox (NFT). 2013b. Yield per recruit (YPR) version 3.2.1. (Internet address: http://nft.nefsc.noaa.gov).

NOAA Fisheries Toolbox (NFT) 2013c. Age Structured Projection Model (AGEPRO) version 4.2. [Internet address: http://nft.nefsc.noaa.gov].

Terceiro M. 2012. Stock assessment of summer flounder for 2012. Northeast Fisheries Science Center Ref Doc. 12-21. 148 p.

Thompson WF, Bell FH. 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific halibut) Comm. 8: 49 p.

Wilk SJ, Smith WG, Ralph DE, Sibunka J. 1980. The population structure of summer flounder between New York and Florida based on linear discriminant analysis. Trans. Am. Fish. Soc. 109:265-271.

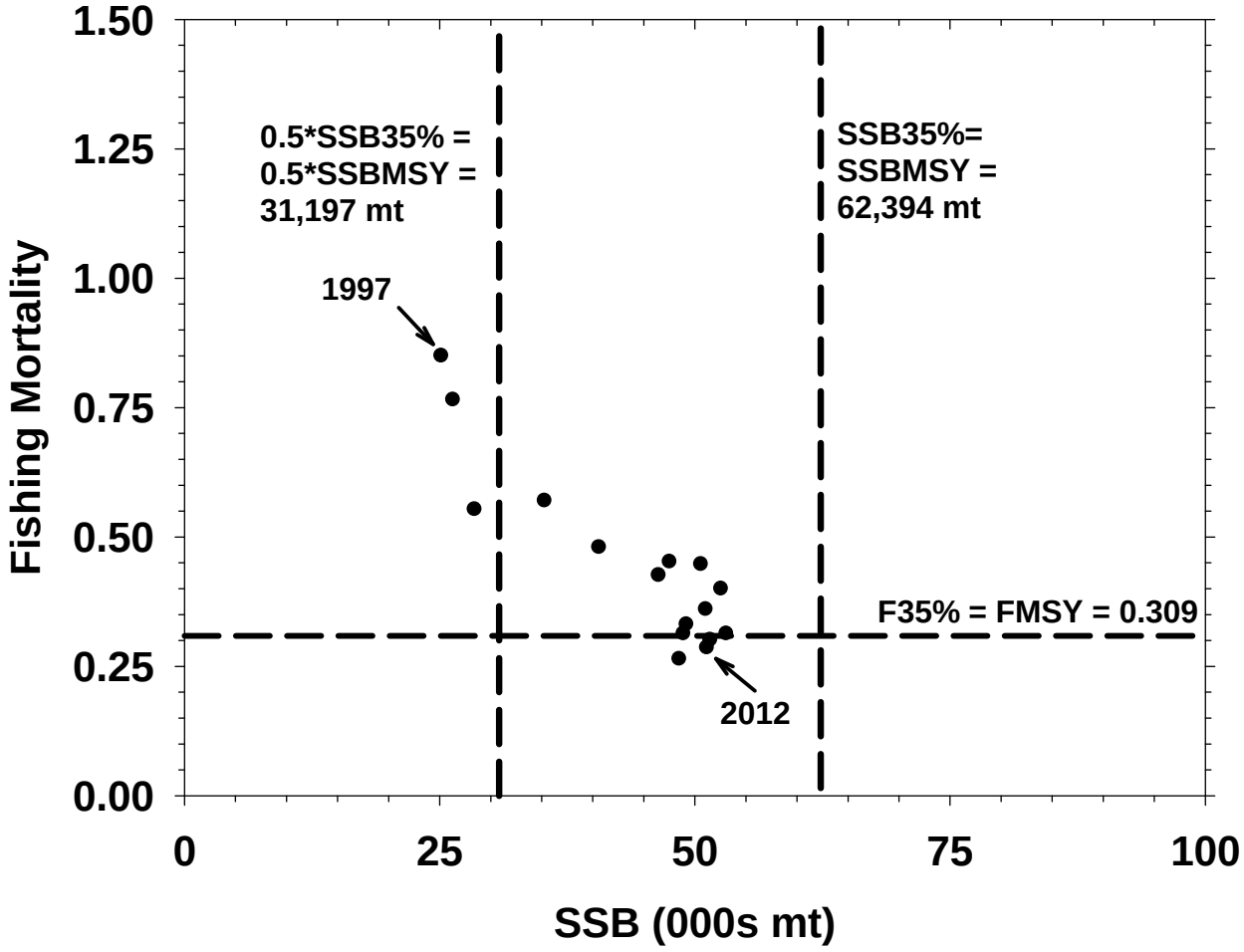

Figure A1. Estimates of summer flounder spawning stock biomass (SSB) and fully-recruited fishing mortality (F, peak at age 4) relative to the 2013 SAW/SARC57 biological reference points.

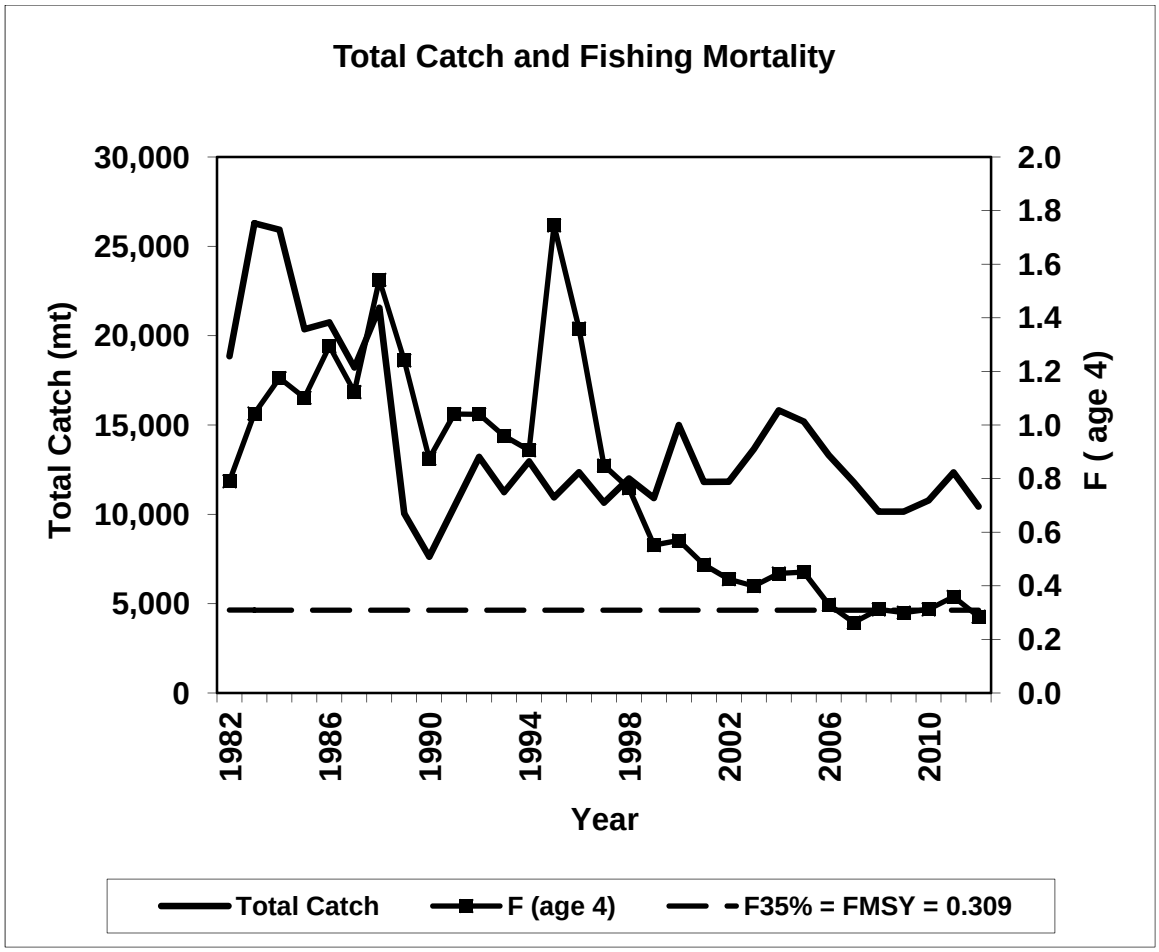

Figure A2. Total fishery catch and fully-recruited fishing mortality (F, peak at age 4) of summer flounder. The horizontal dashed line is the 2013 SAW/SARC57 fishing mortality reference point proxy.

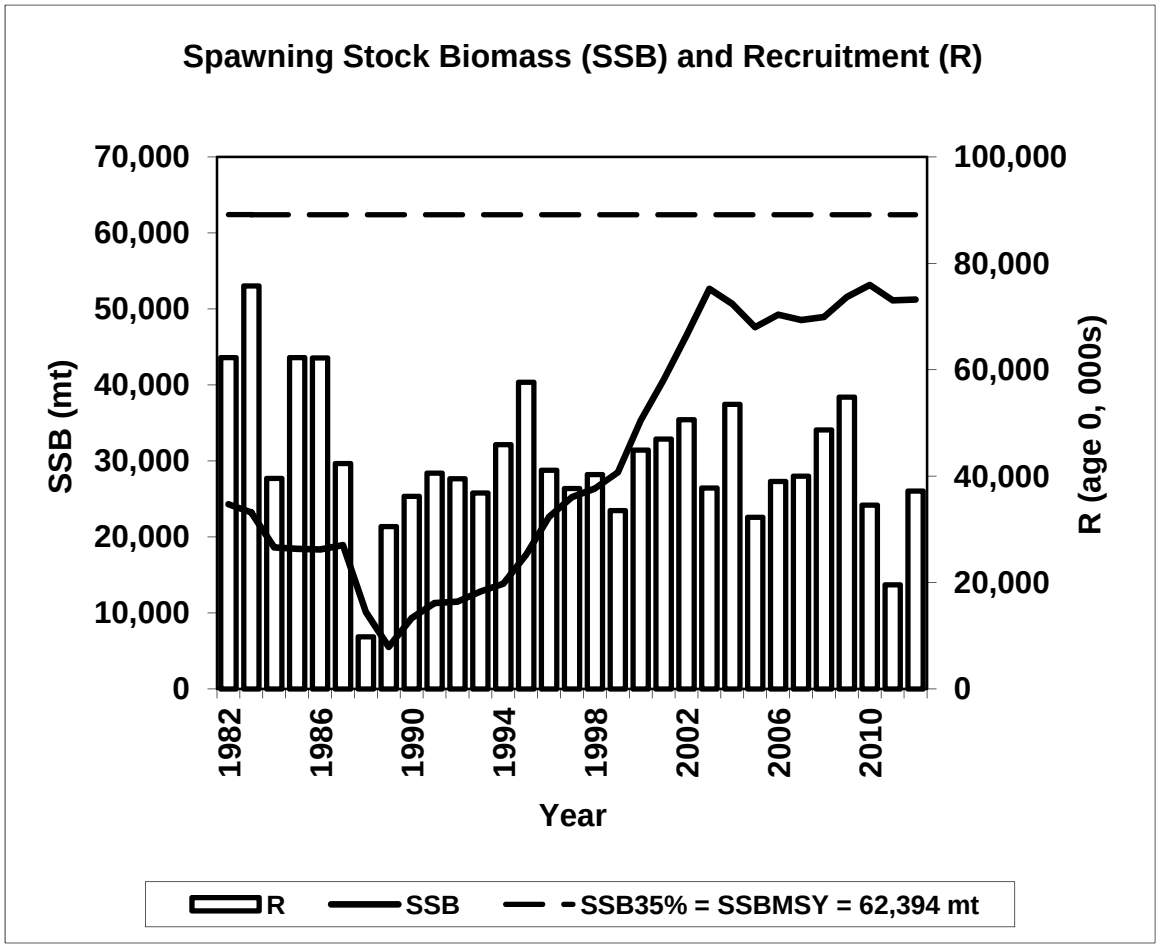

Figure A3. Summer flounder spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year. The horizontal dashed line is the 2013 SAW/SARC57 biomass reference point proxy.

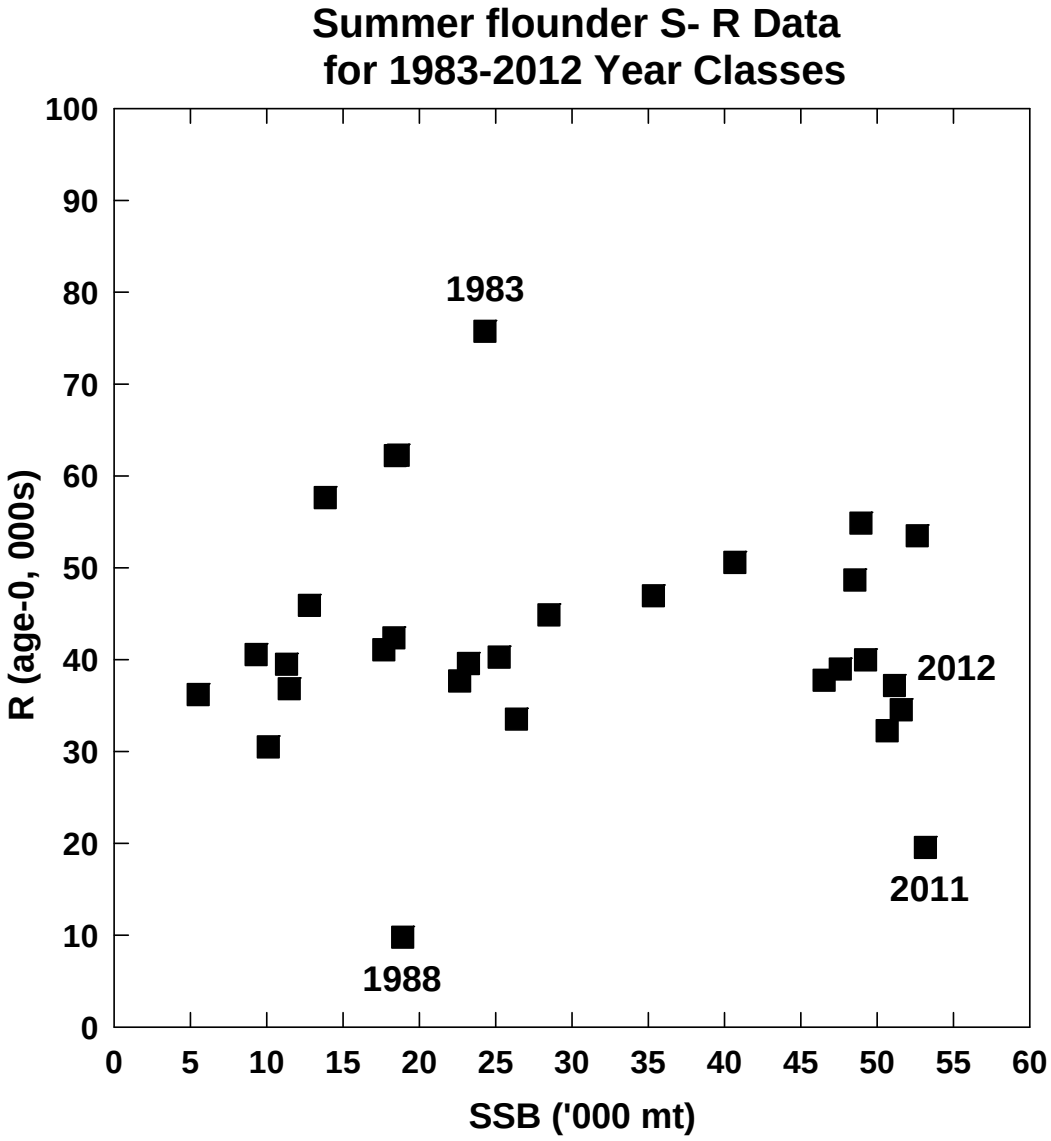

Figure A4. Stock-recruitment scatter plot for the summer flounder 1983-2012 year classes. Highest recruitment point is the 1983 year class (R = 75.5 million, SSB = 24,300 mt); highest SSB point is for the 2011 year class (R = 19.6 million, SSB = 53,156 mt). The 2012 year class is at R = 37.2 million, SSB = 51,100 mt.

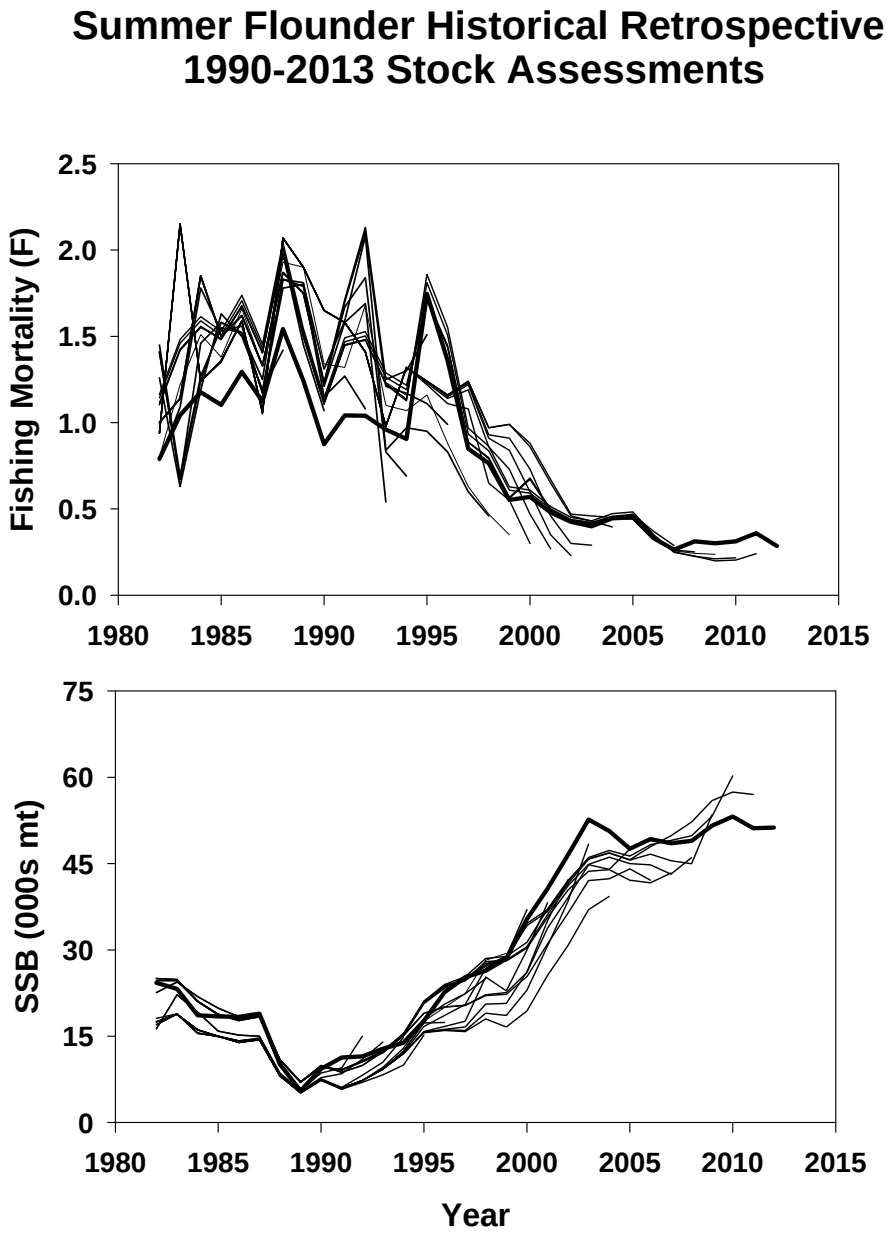

Figure A5. Historical retrospective of the 1990-2013 stock assessments of summer flounder.