Summer Flounder Management Track Assessment for 2021
(Lead: Mark Terceiro)

State of Stock: This 2021 Management Track Assessment (MTA) of summer flounder (*Paralichthys dentatus*) is an update through 2019 of the commercial and recreational fishery catch data and research survey indices of abundance. Assessment model estimates of stock size and fishing mortality are updated through 2019.

The stock was not overfished and overfishing was not occurring in 2019 relative to the updated biological reference points (Figures 1-3). Spawning stock biomass (SSB) was estimated to be 47,397 mt in 2019, 86% of the updated biomass target reference point SSBMSY proxy = SSB35% = 55,217 mt (Table 1, Figures 1, 3). There is a 90% chance that SSB in 2019 was between 42,000 and 54,000 mt. Fishing mortality on the fully selected age 4 fish was 0.340 in 2019, 81% of the updated fishing mortality threshold reference point FMSY proxy = F35% = 0.422 (Table 1, Figure 2). There is a 90% probability that the fishing mortality rate in 2019 was between 0.280 and 0.396**.** The 1983 year class is the largest in the assessment time series at 102 million fish, while the 1988 year class is the smallest at 12 million fish. The average recruitment from 1982 to 2019 is 53 million fish at age 0. Recruitment was below average during 2011-2017, ranging from 31 to 45 million and averaging 36 million fish. The 2018 year class estimated at 61 million fish is above average and the largest since 2009, while the 2019 year class is below average at 49 million fish (Table 1, Figures 3-4). The model estimates of F and SSB in 2019 adjusted for internal retrospective error are within the model estimate 90% confidence intervals and so no adjustment of these terminal year estimates has been made for stock status determination or projections (Figure 1). The recruitment production per unit of spawning stock biomass (R/SSB; a metric of the relative survival of year classes) was higher in the 1980s and early 1990s than in the years since 1996, as the stock has varied near SSBMSY (Figure 5).

OFL Projections: Projections using the results of the 2021 MTA model (data through 2019) were made to estimate the OFL catches for 2022-2023. The projections assume that the 2020 and 2021 ABCs of 11,354 mt and 12,297 mt were caught. **The preliminary estimate of 2020 catch is 11,203 mt, 99% of the 2020 ABC.** The projections sample from the estimated recruitment for the most recent 9 years (2011-2019; average recruitment = 40 million fish). The OFL projections use F2022-F2023 = updated FMSY proxy = F35% = 0.422. The OFL catches are 16,458 mt in 2022 (CV = 14%) and 15,464 mt in 2023 (CV = 12%).

OFL for 2022-2023
Catches and SSB in metric tons

Year	Catch	Landing	Discards	F	SSB
2020	11,354	8,604	2,750	0.328	54,352
2021	12,297	9,468	2,829	0.320	56,920
2022	16,458	12,798	3,620	0.422	54,053
2023	15,464	12,072	3,392	0.422	49,933

Catch: Reported 2019 landings in the commercial fishery were 4,109 mt = 9.059 million lb. Estimated 2019 landings in the recreational fishery were 3,537 mt = 7.798 million lb. Total commercial and recreational landings in 2019 were 7,646 mt = 16.857 million lb. Commercial discards in 2019 were estimated at 783 mt = 1.726 million lb. Recreational discards in 2019 were estimated at 1,379 mt = 3.040 million lb. Total commercial and recreational discards in 2019 were 2,162 mt = 4.770 million lb. The estimated total catch in 2019 was 9,808 mt = 21.623 million lb.

Catch and Status Table: Summer flounder

Catch weights and spawning stock biomass are in metric tons (mt); recruitment is in millions of age 0 fish; min, max and arithmetic mean values are for 1982-2019. Commercial catches are latest reported landings and estimated discards. Recreational catches in the table are 'New' MRIP calibrated landings and discard estimates.

Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Commercial landings	6,078	7,517	5,918	5,696	4,989	4,858	3,537	2,644	2,787	4,109
Commercial discards	1,478	1,143	754	863	830	703	772	906	979	783
Recreational landings	5,142	6,116	7,318	8,806	7,364	5,366	6,005	4,565	3,447	3,537
Recreational discards	2,710	2,711	2,172	2,119	2,092	1,572	1,482	1,496	1,003	1,379
Catch used in assessment	15,408	17,487	16,163	17,483	15,275	12,498	11,796	9,611	8,216	9,808
Spawning stock biomass	62,137	56,467	60,957	53,700	49,600	44,212	41,313	39,516	41,403	47,397
Recruitment (age 0)	51	31	35	37	41	28	33	45	61	49
Fully selected F (age 4)	0.378	0.446	0.409	0.461	0.424	0.419	0.414	0.331	0.286	0.340

Year	**Min**	**Max**	**Mean**
Commercial landings	2,644	17,130	7,018
Commercial discards	219	2,151	1,101
Recreational landings	2,566	16,655	7,644
Recreational discards	84	2,711	1,223
Catch used in assessment	8,216	30,470	16,784
Spawning stock biomass	7,425	67,498	39,053
Recruitment (age 0)	12	102	53
Fully selected F (age 4)	0.254	1.624	0.727

Stock Distribution and Identification: The joint 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 and to the northeast to the US-Canada border. The current management unit is consistent with a summer flounder genetics study which revealed no population subdivision at Cape Hatteras (Jones and Quattro 1999). 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. 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 stock unit used in this assessment is consistent with the conclusions of Wilk et al. (1980) and Kraus and Musick (2003).

Assessment Model: The assessment approach implemented for summer flounder is a complex statistical catch-at-age model incorporating a broad array of fishery and survey data (ASAP SCAA; Legault and Restrepo 1998, NFT 2013a; NEFSC 2013, 2018). The catch in the model includes both commercial and recreational fishery landings and discards at age. The commercial and recreational fishery landings and discards are treated as four separate fleets in the model. The model assumes an averaged-over-ages instantaneous natural mortality rate (M) = 0.25.

Indices of stock abundance, including age compositions from the NEFSC winter, spring, and fall, Massachusetts spring and fall, Rhode Island fall and monthly, 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, Virginia and North Carolina were also used in the model calibration. For the NEFSC indices, the years sampled by the FSV HB Bigelow (2009-2019) were treated as a separate series from the earlier years (1982-2008) that were sampled by the FSV Albatross IV. The Bigelow indices take into account trawl efficiency at length and wing spread by tow. All indices were updated for this assessment.

The summer flounder stock assessment historically exhibited a retrospective pattern of underestimation of F and overestimation of SSB. However, there is not a major retrospective pattern evident in the current summer flounder assessment model. The minor internal model retrospective error tends to overestimate F by +1% and overestimate SSB by +3% over the last 7 terminal years. The model estimates of F and SSB adjusted for internal retrospective error are within the model estimate 90% confidence intervals and so no adjustment of these terminal year estimates has been made for stock status determination or projections. The 'historical' retrospective analysis (comparison between assessments) indicates that the general trends in spawning stock biomass, recruitment, and fishing mortality have been consistent over the history of the assessment (Figure 6).

Biological Reference Points

The 2013 SAW 57 (NEFSC 2013) biological reference points for summer flounder were based on stochastic yield and SSB per recruit and stochastic projection models in the NSAA NFT framework (NEFSC 2013; NFT 2013b, c; Thompson and Bell 1934) using values from the 2013 assessment. The associated threshold fishing mortality reference point was F35% = 0.309 (CV = 15%) as a proxy for FMSY. The biomass reference point proxy was estimated as the projection of stock sizes at F35% = 0.309 and mean recruitment of 43 million fish per year (1982-2012). The SAW-57 target biomass SSBMSY proxy was estimated to be 62,394 mt (137.6 million lb; CV = 13%) and the threshold biomass of one-half SSBMSY was estimated to be 31,197 mt (68.8 million lb; CV = 13%). The MSY proxy was estimated to be 12,945 mt (28.539 million lb; CV = 13%).

The 2018 SAW 66 (NEFSC 2018) biological reference points for summer flounder were similarly based on stochastic yield and SSB per recruit and stochastic projection models. The threshold fishing mortality reference

point estimate was F35% = 0.448 (CV = 15%) as a proxy for FMSY. The biomass reference point proxy was estimated as the projection of stock sizes at F35% = 0.448 and mean recruitment of 53 million fish per year (1982-2017). The target biomass SSBMSY proxy was estimated to be 57,159 mt (126.0 million lb; CV = 15%) and the threshold biomass of one-half SSBMSY was estimated to be 28,580 mt (63.0 million lb; CV = 15%). The MSY proxy was estimated to be 15,973 mt (35.214 million lb; CV = 15%). The increase in the F reference point (and MSY) but decrease in the biomass reference point compared to the 2013 SAW 57 values were a result of changes in mean weights at age and selectivity.

The F35% and corresponding SSB35% proxy biological reference points for summer flounder were updated for this 2021 MTA. The updated fishing mortality threshold F35% proxy for FMSY = 0.422 (CV = 15%). The updated biomass target proxy estimate for SSBMSY = SSB35% = 55,217 mt (122 million lb; CV = 15%) and the updated biomass threshold proxy estimate for one-half SSBMSY = one-half SSB35% = 27,609 mt (61 million lb; CV = 15%). The updated MSY proxy = 15,872 mt (35 million lb; CV = 15%).

Qualitative status description:

The age structure in current fishery and survey catches is greatly expanded compared to the truncated distribution observed in the late 1980s to early 1990s. Although survey indices and model estimates of recruitment have generally been below average in recent years, the driver of this pattern has not been identified and it is not clear if this pattern will persist in the future (NEFSC 2018). The recent 2018 year class is above average and the largest to recruit to the stock since 2009, while the 2019 year class is below average.

Research and Data Issues:

2018 SAW 66

Continue to explore changes in the distribution of recruitment. Develop studies, sampling programs, or analyses to better understand how and why these changes are occurring, and the implications to stock productivity: *no new research progress, note that recruitment improved in 2018-2019*

The reference points are internally consistent with the current assessment. It may be useful to carry uncertainty estimates through all the components of the assessment, BRPs, and projections*: no new research progress, models of S-R data continue to indicate that steepness is very close to 1*

Explore the potential mechanisms for recent slower growth that is observed in both sexes: *no new research progress, ongoing monitoring in assessment*

MAFMC SSC 2019-2020

Evaluate the causes of decreased recruitment and changes in the recruit per spawner relationship in recent years: *no new research progress, however, note that R/SSB ratio has stabilized as the stock has varied near BMSY*

Evaluate uncertainties in biomass to determine potential modifications to the OFL
CV employed: *SSC has developed new procedures for establishing the OFL CV*

Evaluate fully the sex and size distributions of landed and discarded fish in the Summer Flounder fisheries: *no progress in implementing by-sex fishery sampling*

Evaluate the effects of past and possible future changes to size regulations on retention and selectivity in stock assessments and projections: *ongoing monitoring in assessment*

Incorporate sex-specific differences in size-at-age into the stock assessment through model structures as well as data streams: *no new data streams; however ASAP by-sex model updated through 2018 and NEFSC WHAM state-space by-sex model in development*

Validate the otolith-based age determination*: no explicit validation, however, going aging method exchanges have insured consistency among the major aging labs (NEFSC, NCDMF, VIMS, ODU, CTDEEP, and NYDEC)*

Further develop understanding of effects of ecosystem changes (e.g., temperature, trophic structure changes) on population dynamics: *new publication in the primary literature (O'Leary et al. 2019, a,b; Gulf Stream Index and exploitation influences on growth and natural mortality).*

The MAMFC SSC expressed some concern in 2020 that the rebuilding of the stock does appear to be rapid. It was noted that rebuilding was predicted to be slow under the harvest policy adopted: *updated projections through 2023 in the 2021 MTA*

The above average 2018 year class will not fully recruit to the fishery for 3 or 4 years (2021-2022). There are concerns about increasing discards during this transition. Quantify the size, magnitude, and uncertainty of the discards: *updated estimates of discards through 2019 in the 2021 MTA*

Verifying the strength of the 2018 year class based on a synthesis of the various surveys included in the assessment. (3 years of data on this year class will be available): *only 1 complete year of surveys available (2019) due to survey cancellations and limited fishery sample data in 2020*

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Tables

Table 1. Summary assessment results for summer flounder; Spawning Stock Biomass (SSB) in metric tons (mt); Recruitment (R) at age 0 in thousands; Fishing mortality (F) for age of peak fishery selection age (S = 1 at age 4).

Year	SSB	R	F
1982	30,495	81,800	0.746
1983	28,928	101,925	1.076
1984	24,283	46,637	1.228
1985	21,792	77,833	1.257
1986	22,152	80,928	1.332
1987	22,859	53,742	1.285
1988	12,567	12,412	1.624
1989	7,425	36,821	1.284
1990	12,112	43,817	0.857
1991	14,058	47,513	1.064
1992	13,077	47,093	1.179
1993	14,550	43,789	1.006
1994	15,921	58,204	0.958
1995	21,072	78,066	1.449
1996	28,850	59,204	1.164
1997	35,527	52,048	0.765
1998	35,172	54,069	0.790
1999	36,039	43,641	0.572
2000	40,731	59,752	0.682
2001	51,708	63,956	0.456
2002	60,095	66,736	0.419
2003	67,498	49,184	0.404
2004	62,534	70,761	0.433
2005	58,923	39,791	0.452
2006	62,295	47,732	0.333
2007	61,370	52,195	0.254
2008	61,847	61,846	0.321
2009	63,421	73,524	0.342
2010	62,137	50,724	0.378
2011	56,467	31,381	0.446
2012	60,957	34,576	0.409
2013	53,700	36,792	0.461
2014	49,600	41,146	0.424
2015	44,212	28,416	0.419
2016	41,313	33,088	0.414
2017	39,516	44,582	0.331
2018	41,403	60,598	0.286
2019	47,397	48,689	0.340

Table 2. Total catch (metric tons) of summer flounder from Maine through North Carolina. Includes the 'New' MRIP calibrated estimates of recreational catch.

Year	Comm Landings	Comm Discards	Comm Catch	Recr Landings	Recr Discards	Recr Catch	Total Landings	Total Discards	Total Catch
1982	10,400	n/a	10,400	10,758	250	11,008	21,158	250	21,408
1983	13,403	n/a	13,403	16,665	356	17,022	30,068	356	30,425
1984	17,130	n/a	17,130	12,803	537	13,340	29,933	537	30,470
1985	14,675	n/a	14,675	11,405	184	11,589	26,080	184	26,264
1986	12,186	n/a	12,186	12,005	646	12,651	24,191	646	24,837
1987	12,271	n/a	12,271	10,638	668	11,306	22,909	668	23,577
1988	14,686	n/a	14,686	9,429	483	9,912	24,115	483	24,598
1989	8,125	456	8,581	2,566	84	2,650	10,691	540	11,231
1990	4,199	898	5,097	3,517	414	3,931	7,716	1,312	9,028
1991	6,224	219	6,443	5,854	617	6,470	12,078	836	12,914
1992	7,529	2,151	9,680	5,746	559	6,305	13,275	2,710	15,985
1993	5,715	701	6,416	6,228	703	6,931	11,943	1,404	13,347
1994	6,588	1,539	8,127	6,481	409	6,889	13,069	1,947	15,016
1995	6,977	827	7,804	4,090	589	4,679	11,067	1,415	12,482
1996	5,861	1,436	7,297	6,813	624	7,437	12,674	2,060	14,734
1997	3,994	807	4,801	8,403	663	9,066	12,397	1,470	13,867
1998	5,076	638	5,714	10,368	997	11,365	15,444	1,635	17,079
1999	4,820	1,666	6,486	7,573	1,078	8,651	12,393	2,744	15,138
2000	5,085	1,620	6,705	12,259	1,182	13,441	17,344	2,802	20,146
2001	4,970	411	5,381	8,417	1,897	10,314	13,387	2,308	15,695
2002	6,573	948	7,521	7,388	1,564	8,952	13,961	2,512	16,473
2003	6,450	1,160	7,610	9,746	1,867	11,614	16,196	3,028	19,224
2004	7,880	1,628	9,508	9,616	1,833	11,449	17,496	3,461	20,958
2005	7,671	1,499	9,170	8,412	1,711	10,123	16,083	3,210	19,293
2006	6,316	1,518	7,834	8,452	1,583	10,034	14,768	3,100	17,868
2007	4,544	2,128	6,672	6,300	1,801	8,101	10,844	3,929	14,773
2008	4,179	1,162	5,341	5,597	1,970	7,567	9,776	3,132	12,909
2009	5,013	1,522	6,535	5,288	2,484	7,771	10,301	4,006	14,307
2010	6,078	1,478	7,556	5,142	2,710	7,852	11,220	4,188	15,408
2011	7,517	1,143	8,660	6,116	2,711	8,827	13,633	3,854	17,487
2012	5,918	754	6,672	7,318	2,172	9,490	13,236	2,927	16,163
2013	5,696	863	6,559	8,806	2,119	10,925	14,502	2,981	17,483
2014	4,989	830	5,819	7,364	2,092	9,456	12,353	2,922	15,275
2015	4,858	703	5,561	5,366	1,572	6,938	10,224	2,274	12,498
2016	3,537	772	4,309	6,005	1,482	7,487	9,542	2,254	11,796
2017	2,644	906	3,550	4,565	1,496	6,061	7,209	2,402	9,611
2018	2,787	997	3,784	3,447	1,003	4,450	6,234	1,982	8,216
2019	4,103	783	4,892	3,537	1,379	4,916	7,646	2,162	9,808

Figures

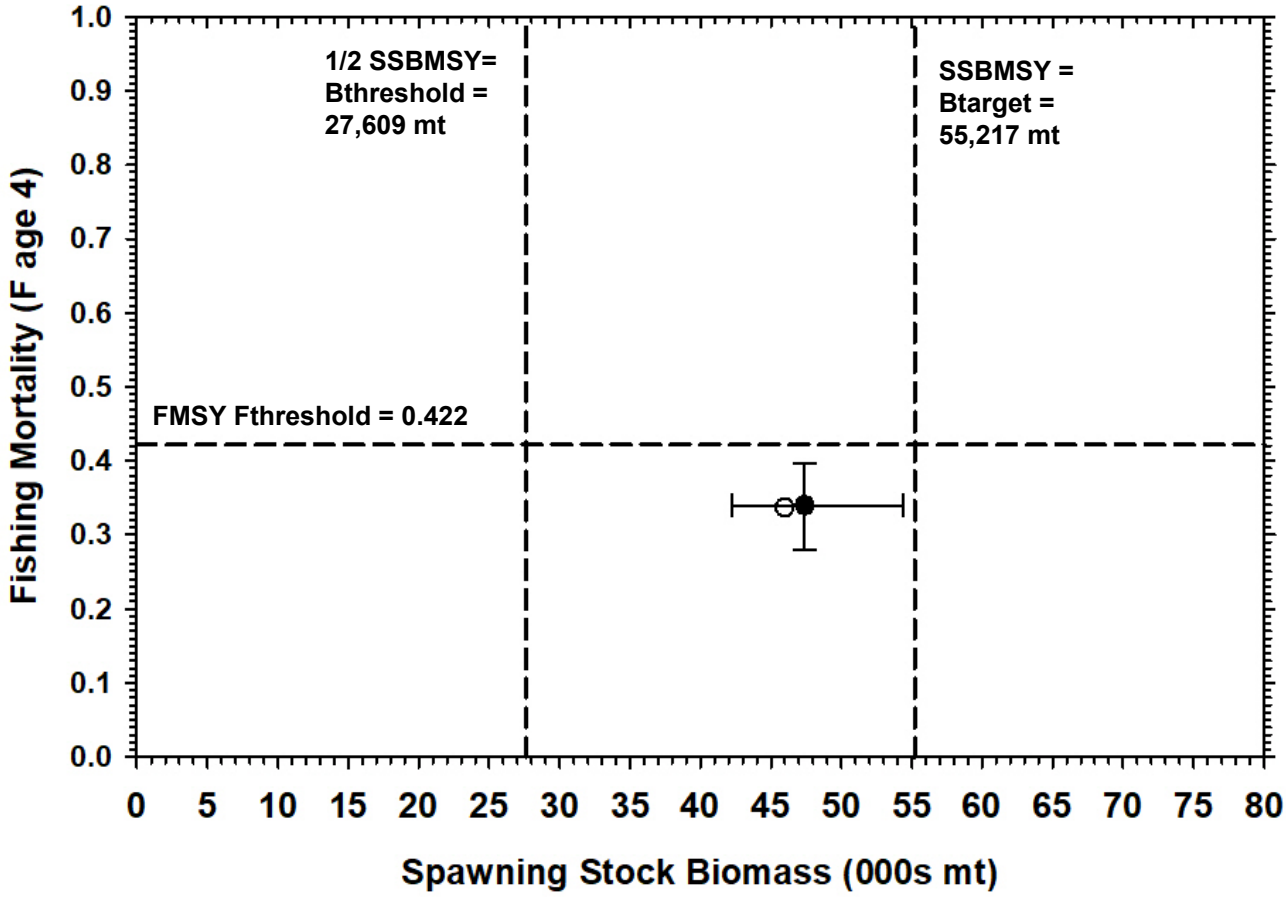

Figure 1. Estimates of summer flounder spawning stock biomass (SSB) and fully-recruited fishing mortality (F, peak at age 4) relative to the updated 2021 MTA biological reference points. The filled circle with 90% confidence intervals shows the assessment point estimates. The open circle shows the retrospectively adjusted estimates.

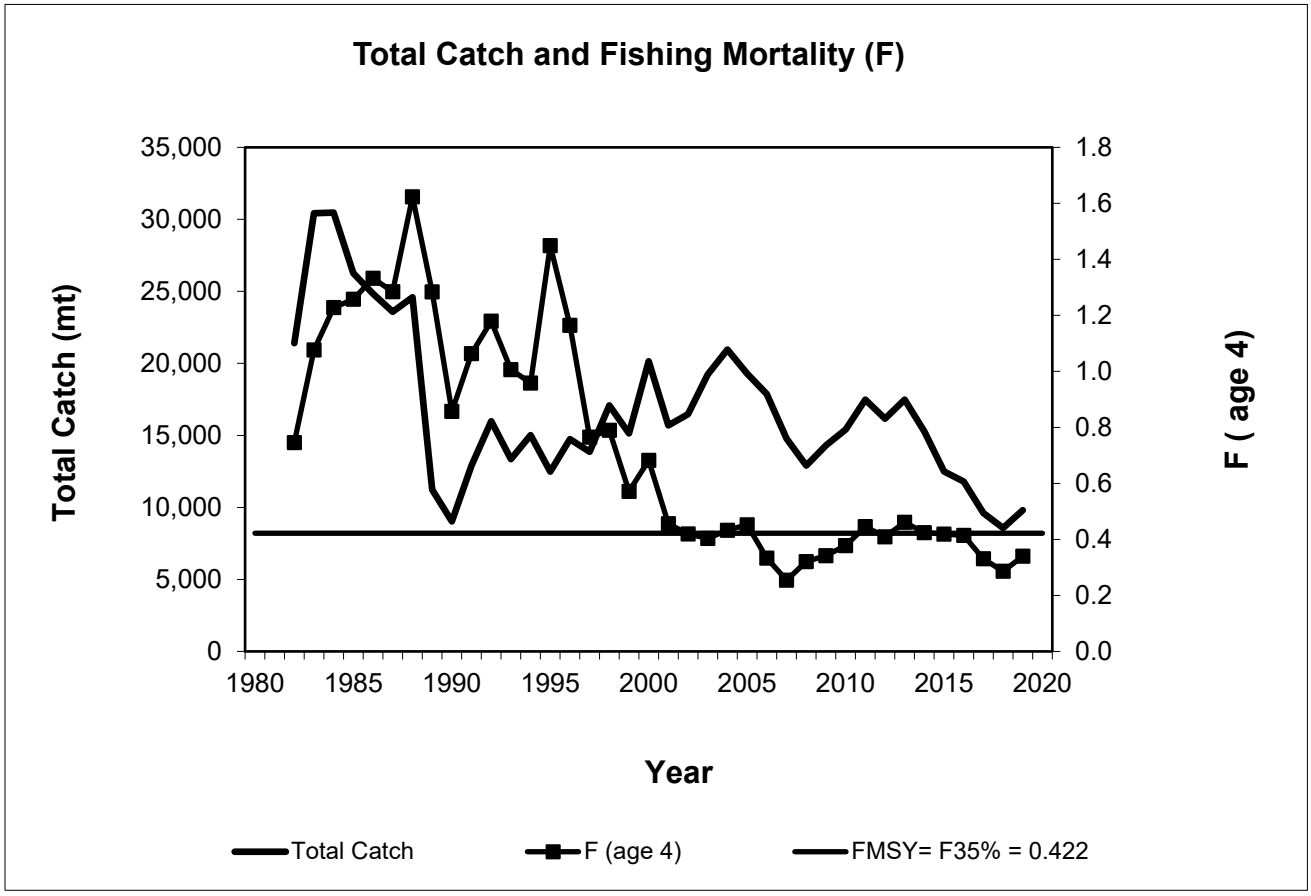

Figure 2. Total fishery catch (metric tons; mt; solid line) and fully-recruited fishing mortality (F, peak at age 4; squares) of summer flounder through 2019. The horizontal solid line is the updated 2021 MTA threshold fishing mortality reference point proxy.

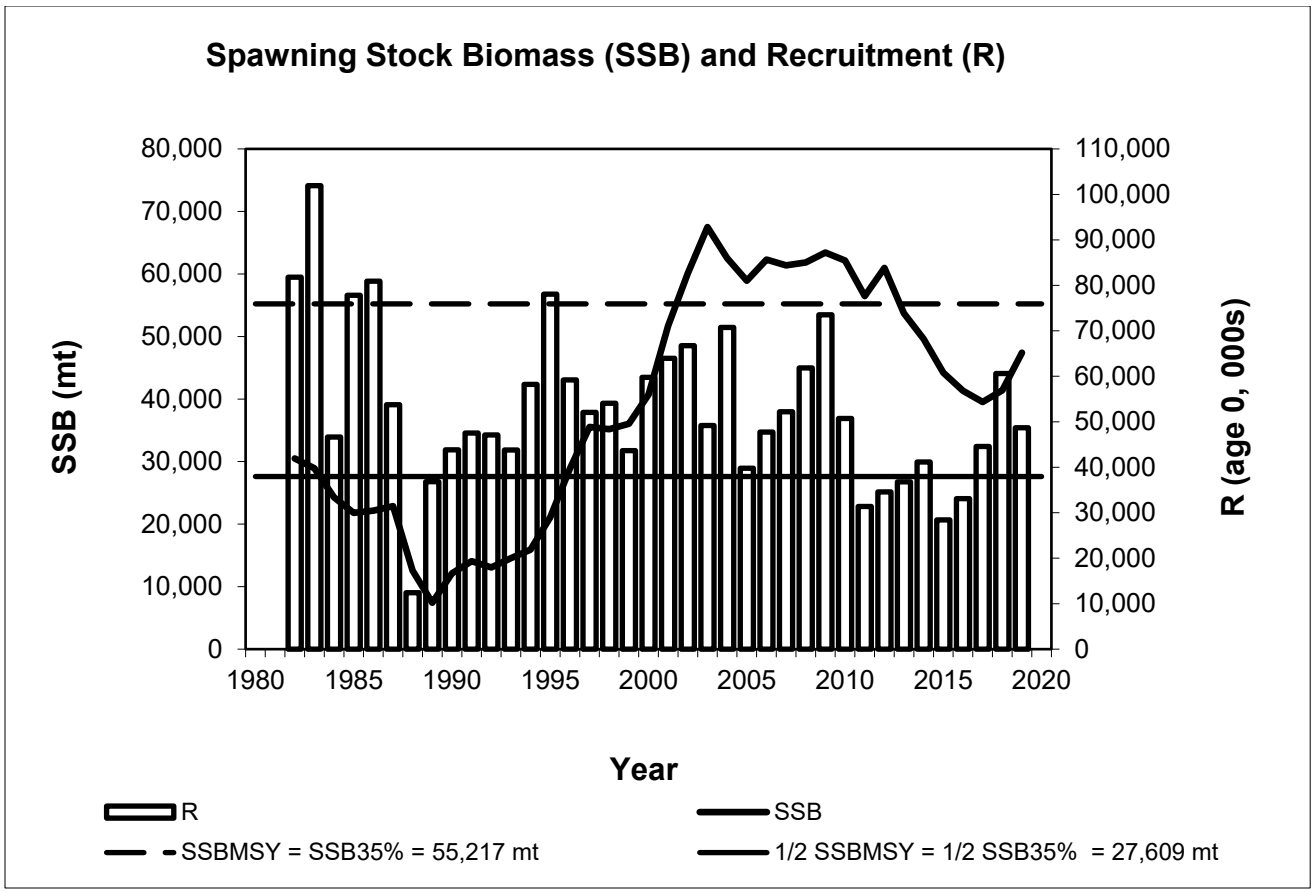

Figure 3. Summer flounder spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year through 2019. The horizontal dashed line is the updated 2021 MTA target biomass reference point proxy. The horizontal solid line is the updated 2021 MTA threshold biomass reference point proxy.

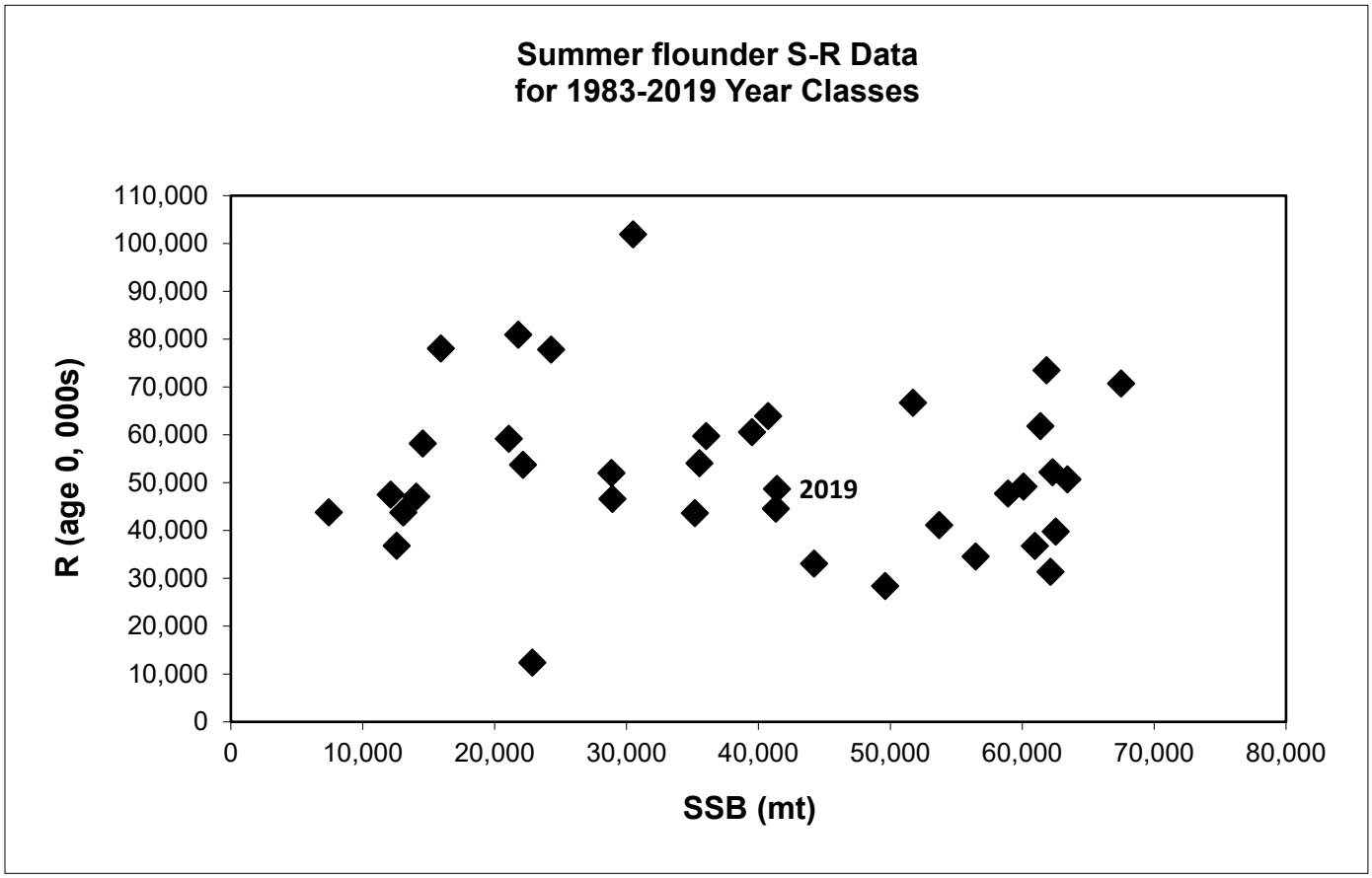

Figure 4. Stock-recruitment (SSB-R) scatter plot for the summer flounder 1983-2019 year classes. The largest recruitment (R) point is for the 1983 year class (R = 102 million, SSB = 30,495 mt). The lowest recruitment point is for the 1988 year class (R = 12 million, SSB = 22,859 mt). The 2018 year class is at R = 61 million, SSB = 39,516 mt; the 2019 year class is at R = 48 million, SSB = 41,403 mt.

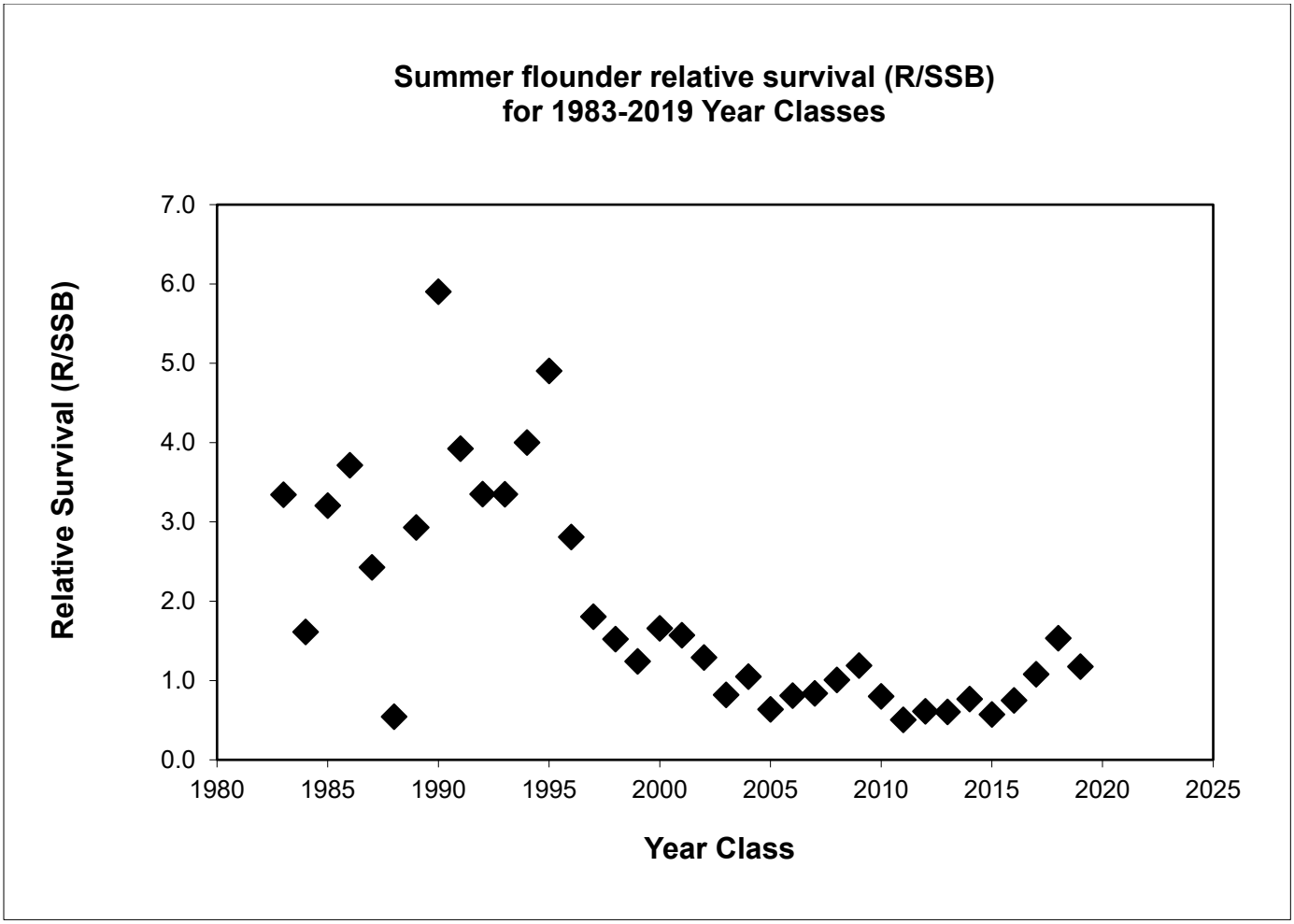

Figure 5. Recruits per Spawning Stock Biomass plot (R/SSB) indicative of the relative survival of the summer flounder 1983-2019 year classes.

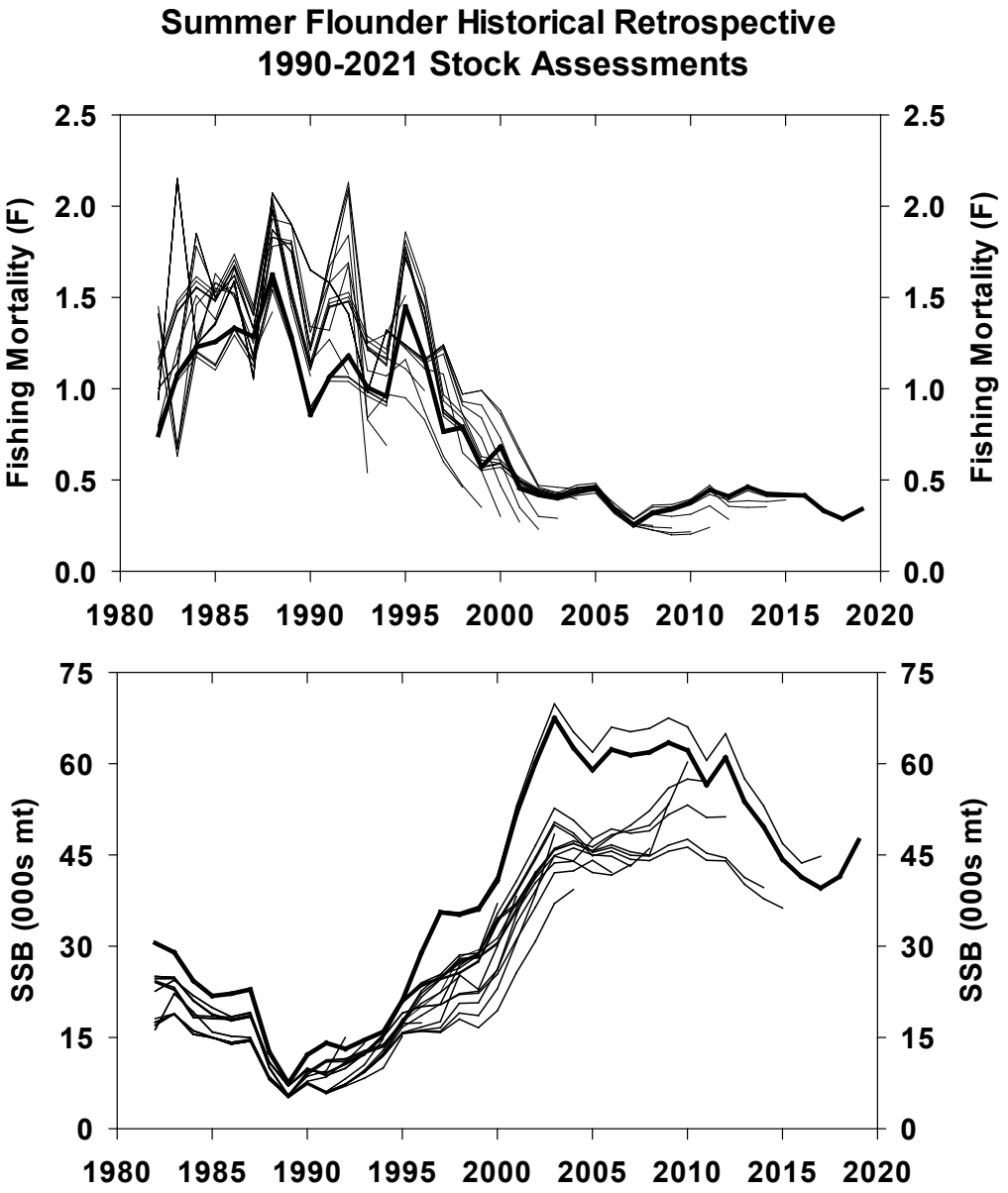

Figure 6. Historical retrospective of the 1990-2021 stock assessments of summer flounder. The heavy solid lines are the 2021 MTA model estimates.