## 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 $47,397 \mathrm{mt}$ in 2019, 86\% of the updated biomass target reference point SSBMSY proxy $=\mathrm{SSB} 35 \%=55,217 \mathrm{mt}$ (Table 1, Figures 1, 3). There is a $90 \%$ chance that SSB in 2019 was between 42,000 and $54,000 \mathrm{mt}$. 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 $=\mathrm{F} 35 \%=$ 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 $11,354 \mathrm{mt}$ and $12,297 \mathrm{mt}$ were caught. The preliminary estimate of $\mathbf{2 0 2 0}$ catch is $\mathbf{1 1 , 2 0 3} \mathbf{~ m t , ~ 9 9 \%}$ of the $\mathbf{2 0 2 0} \mathbf{A B C}$. 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 $=\mathrm{F} 35 \%=0.422$. The OFL catches are 16,458 mt in $2022(\mathrm{CV}=14 \%)$ and 15,464 mt in $2023(\mathrm{CV}=12 \%)$.

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 $4,109 \mathrm{mt}=9.059$ million lb. Estimated 2019 landings in the recreational fishery were $3,537 \mathrm{mt}=7.798$ million lb . Total commercial and recreational landings in 2019 were $7,646 \mathrm{mt}=16.857$ million lb. Commercial discards in 2019 were estimated at $783 \mathrm{mt}=1.726$ million lb . Recreational discards in 2019 were estimated at $1,379 \mathrm{mt}=3.040$ million lb . Total commercial and recreational discards in 2019 were $2,162 \mathrm{mt}=4.770$ million lb . The estimated total catch in 2019 was $9,808 \mathrm{mt}=$ 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 $\mathrm{F} 35 \%=0.309(\mathrm{CV}=15 \%)$ as a proxy for FMSY . The biomass reference point proxy was estimated as the projection of stock sizes at $\mathrm{F} 35 \%=0.309$ and mean recruitment of 43 million fish per year (19822012). The SAW-57 target biomass SSBMSY proxy was estimated to be $62,394 \mathrm{mt}$ ( 137.6 million lb; CV $=13 \%$ ) and the threshold biomass of one-half SSBMSY was estimated to be $31,197 \mathrm{mt}$ ( 68.8 million lb; $\mathrm{CV}=13 \%$ ). The MSY proxy was estimated to be $12,945 \mathrm{mt}$ ( 28.539 million $\mathrm{lb} ; \mathrm{CV}=13 \%$ ).

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 $\mathrm{F} 35 \%=0.448(\mathrm{CV}=15 \%)$ as a proxy for FMSY. The biomass reference point proxy was estimated as the projection of stock sizes at $\mathrm{F} 35 \%=0.448$ and mean recruitment of 53 million fish per year (19822017). The target biomass SSBMSY proxy was estimated to be $57,159 \mathrm{mt}(126.0$ million lb ; $\mathrm{CV}=15 \%$ ) and the threshold biomass of one-half SSBMSY was estimated to be $28,580 \mathrm{mt}$ ( 63.0 million $\mathrm{lb} ; \mathrm{CV}=15 \%$ ). The MSY proxy was estimated to be $15,973 \mathrm{mt}$ ( 35.214 million $\mathrm{lb} ; \mathrm{CV}=15 \%$ ). 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 $\mathrm{SSBMSY}=\mathrm{SSB} 35 \%=55,217 \mathrm{mt}(122$ million $\mathrm{lb} ; \mathrm{CV}=15 \%)$ and the updated biomass threshold proxy estimate for one-half SSBMSY $=$ one-half $\operatorname{SSB} 35 \%=27,609 \mathrm{mt}$ ( 61 million lb ; $\mathrm{CV}=15 \%$ ). The updated MSY proxy $=15,872 \mathrm{mt}$ ( 35 million $\mathrm{lb} ; \mathrm{CV}=15 \%$ ).

## 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 $R / S S B$ 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 $(\mathrm{R})$ at age 0 in thousands; Fishing mortality ( F ) for age of peak fishery selection age ( $\mathrm{S}=1$ 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 <br> Landings | Comm <br> Discards | Comm <br> Catch | Recr Landings | Recr <br> 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 | $\mathrm{n} / \mathrm{a}$ | 13,403 | 16,665 | 356 | 17,022 | 30,068 | 356 | 30,425 |
| 1984 | 17,130 | $\mathrm{n} / \mathrm{a}$ | 17,130 | 12,803 | 537 | 13,340 | 29,933 | 537 | 30,470 |
| 1985 | 14,675 | $\mathrm{n} / \mathrm{a}$ | 14,675 | 11,405 | 184 | 11,589 | 26,080 | 184 | 26,264 |
| 1986 | 12,186 | $\mathrm{n} / \mathrm{a}$ | 12,186 | 12,005 | 646 | 12,651 | 24,191 | 646 | 24,837 |
| 1987 | 12,271 | $\mathrm{n} / \mathrm{a}$ | 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, $S S B=30,495 \mathrm{mt})$. The lowest recruitment point is for the 1988 year class ( $\mathrm{R}=12$ million, $\mathrm{SSB}=22,859 \mathrm{mt}$ ). The 2018 year class is at $\mathrm{R}=61$ million, $\mathrm{SSB}=39,516 \mathrm{mt}$; the 2019 year class is at $\mathrm{R}=48$ million, $\mathrm{SSB}=41,403 \mathrm{mt}$.


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.

