A: Black Sea Bass Operational Assessment for 2021

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State of Stock: This assessment of black sea bass (*Centropristis striata*) is an update through 2019 of commercial and recreational catch data, research survey and fishery-dependent indices of abundance, and the analyses of those data. The black sea bass stock was not overfished and overfishing was not occurring in 2019 relative to the updated biological reference points (Figure A1). Spawning stock biomass (retro adjusted SSB) was estimated to be 30,774 mt in 2019, about 2.2 times the updated biomass target reference point SSB_{MSY} proxy = $SSB_{40\%}$ = 14,441 mt (Table A1, Figure A2). There is a 90% chance that SSB in 2019 was between 23,846 and 39,352 mt. Fishing mortality on the fully selected ages 6-7 fish was 0.39 in 2019 after adjusting for retrospective biases, which was 85% of the updated fishing mortality threshold reference point F_{MSY} proxy = $F_{40\%}$ = 0.46 (Table A1, Figure A3). There is a 90% probability that the fishing mortality rate in 2019 was between 0.30 and 0.53. The average recruitment from 1989 to 2018 is 39 million fish at age 1. The 2011 year class was estimated to be the largest in the time series at 170.4 million fish and the 2015 year class was the second largest at 93.8 million fish. Recruitment of the 2017 year class as age 1 in 2018 was estimated at 14.9 million, well below average. The 2018 year class at age 1 in 2019 was estimated at 46.2 million and 79.4 million with retro adjustment (Table A1, Figures A2 & A4). The 2019 model estimates of F and SSB adjusted for internal retrospective error are outside the model estimate 90% confidence intervals and so the terminal year estimates have been adjusted for stock status determination and projections (Figure A1).

OFL Projections: Projections using the 2021 Operational Assessment ASAP model (data through 2019) were made to estimate the OFL catches for 2022-2023. The projections assume the 2020 catch at the ABC plus an adjustment for actual 2020 recreational landings. Catch in 2021 is assumed as the ABC. Incoming recruitment was sampled from the estimated recruitment for 1989-2019. The OFL projection for combined regions uses F_{2022}-F_{2023} = updated F_{MSY} proxy = $F40\%$ = 0.46 (north) and 0.45 (south). The OFL catches are 9,383 mt in 2022 (CV =19%) and 8,014 mt in 2021 (CV =17%).

OFL for 2022-2023
Catches and SSB in metric tons

Year	Total Catch	F	SSB
2020	8,271	0.33	26,385
2021	6,835	0.29	26,256
2022	9,383	0.46	24,096
2023	8,014	0.46	20,166

Catch: Reported 2019 commercial landings were 1,579 mt = 3.482 million lbs. Estimated 2019 recreational landings were 3,914 mt = 8.630 million lbs. Total commercial and recreational landings in

2019 were 5,493 mt = 12.112 million lbs. Estimated 2019 commercial discards were 1,027 mt = 2.265 million lbs. Estimated 2019 recreational discards were 1,468 mt = 3.237 million lbs. The estimated total catch in 2019 was 7,988 mt = 17.614 million lbs. (Catch and Status Table below; Table A2).

Catch and Status Table: Black Sea Bass
(Weights in mt, recruitment in millions, arithmetic means, includes New MRIP estimates)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Commercial landings	765	782	1,027	1,088	1,113	1,133	1,808	1,514	1,579
Commercial discards[2]	227	116	278	459	423	757	1,027	722	1,027
Recreational landings	1,421	3,162	2,685	3,510	4,448	6,131	5,692	4,008	3,914
Recreational discards[2]	358	1,048	749	839	985	1,391	1,634	1,033	1,468
Catch used in assessment	2,771	5,108	4,739	5,896	6,969	9,412	10,162	7,277	7,988
Spawning stock biomass	14,925	15,116	18,134	26,908	41,121	40,481	38,191	33,124	20,025
Recruitment (age 1, millions)	42.8	170.4	54.8	30.6	39.6	93.8	51.2	14.9	46.2
F full[3]	0.41	0.57	0.53	0.39	0.30	0.31	0.45	0.34	0.47

[1] Years 1989-2019

[2] dead discards

[3] F on fully selected ages 6-7. Note that table values are not retro adjusted.

Year	Min[1]	Max[1]	Avg[1]
Commercial landings	523	1,808	1,177
Commercial discards[2]	10	1,027	239
Recreational landings	681	6,131	2,448
Recreational discards[2]	99	1,634	626
Catch used in assessment	2,263	10,162	4,491
Spawning stock biomass	3,116	41,121	13,233
Recruitment (age 1, millions)	10.1	167.4	38.8
F full[3]	0.30	1.15	0.65

[1] Years 1989-2019

[2] dead discards

[3] Average F on fully selected ages 6-7.

Note that table values are not retro adjusted.

Stock Distribution and Identification

The Mid-Atlantic Fishery Management Council (MAFMC) and Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan for black sea bass defines the management unit as all black sea bass from Cape Hatteras, North Carolina northeast to the US-Canada border (MAFMC 1999). The stock was partitioned into two sub-units to account for spatial differences in the assessment model. The sub-units are not considered to be separate stocks.

Assessment Model: The assessment models (separate north and south models) for black sea bass is a complex statistical catch-at-age model (ASAP SCAA; Legault and Restrepo 1998; NFT 2013) incorporating a broad range of fishery and survey data (NEFSC 2017). The model assumes an instantaneous natural mortality rate (M) = 0.4. The fishery catch in each region is modeled as two fleets: trawl catch and non-trawl catch, which includes recreational landings, recreational discards, commercial fish pot and hand-line catch and catches from other non-trawl sources.

Indices of stock abundance for the north region used in the model were from NEFSC Albatross spring, MA DMF spring trawl, RI DFW spring trawl, CT DEEP spring Long Island trawl, New York DEC juvenile seine, NEFSC Bigelow spring, NEAMAP spring bottom trawl and MRIP catch per angler trip. The indices of abundance for the southern region were from NEFSC Albatross winter, NEFSC Albatross spring, New Jersey DEP spring trawl, DE DFW spring trawl, MD DNR spring coastal bays trawl, VIMS Chesapeake Bay juvenile trawl, NEAMAP spring trawl, NEFSC Bigelow spring trawl and MRIP catch per angler trip. Indices for both regions were comparable to those used in the 2016 benchmark assessment.

There remains a significant retrospective pattern in both the northern and southern assessment models. The retrospective pattern in the north over-estimates F by 62% over the last 5 terminal years and under-estimates SSB by 46%. In the southern region, the opposite pattern prevails where F is under-estimated by 16% and SSB is over-estimated by 16%. The 2019 regional model estimates of average F and SSB were adjusted for internal retrospective error (north F (0.56) adjusted for retrospective = 0.34, north SSB (13,438 mt) adjusted for retrospective = 24,968 mt; south F (0.41) adjusted for retrospective = 0.48, south SSB (5,428 mt) adjusted for retrospective = 4,700 mt). Since the retrospective corrected values generally fell outside the 90% confidence intervals of the terminal year estimates, the retrospective adjusted values were used for status determination and OFL's. The historical retrospective analysis (comparison between assessments) indicates that the trends in spawning stock biomass, recruitment and fishing mortality have been consistent between the benchmark assessment (2016) and the 2021 update.

Biological Reference Points (BRPs): Reference points were calculated using the non-parametric yield and SSB per recruit long-term projection approach. The cumulative distribution function of the 2000-2019 recruitments (equivalent to years used in 2016 benchmark assessment) was re-sampled to provide future recruitment estimates for the projections used to estimate the biomass reference point.

The existing biological reference points for black sea bass are from the 2019 Operational Assessment. The reference points are $F40\%$ as the proxy for F_{MSY}, and the corresponding $SSB40\%$ as the proxy for the SSB_{MSY} biomass target. The $F40\%$ proxy for $F_{MSY} = 0.46$; the proxy estimate for $SSB_{MSY} = SSB40\% = 14,092$ mt = 31.067 million lbs; the proxy estimate for the $\frac{1}{2}$ SSB_{MSY} biomass threshold = $\frac{1}{2}$ $SSB40\% = 7,046$ mt = 15.534 million lbs; and the proxy estimate for MSY = MSY40% = 4,773 mt=10.522 million lbs.

The $F40\%$ and corresponding $SSB40\%$ proxy biological reference points for black sea bass were updated for this 2021 Operational Assessment. The update fishing mortality threshold $F40\%$ proxy for $F_{MSY} = 0.46$. The updated biomass target proxy estimate for $SSB_{MSY} = SSB40\% = 14,441$ mt = 31.837 million lbs. and the updated biomass threshold proxy estimate for $\frac{1}{2}$ $SSB_{MSY} = \frac{1}{2}$ $SSB40\% = 7,221$ mt = 15.919 million lbs. The update proxy estimate for MSY = MSY40% = 5,334 mt =11.760 million lbs.

Qualitative status description:

The distribution of the fishery and catches has shifted north over the past decade. Most survey aggregate biomass indices are near their time series high. Recent survey indices suggest the recruitment of a large 2011 year class in the northern region and a strong 2015 year class in both regions. The 2017 cohort was well below average while the 2018 cohort is above average. Modest total catches over the past few years

would indicate that current mortality from all sources is lower than recent recruitment inputs to the stock, which has resulted in a spawning biomass that is well above the management target.

Research and Data Issues:

The recent recruitment of large year classes in the assessment time series (the 2011 and 2015 year class) has contributed to increases in catch, particularly in the northern region. Additional research examining recruitment events, distribution shifts and the changing environment should be explored.

Spatial differences in recruitment and fisheries have been accounted for with independent assessment models for north and south regions. A single model which tracks the spatial differences in the population dynamics should be developed.

Allocation issues continue to be an important management issue. Development of a Management Strategy Evaluation (MSE) model could be helpful in determining the best approach.

References:

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

Mid-Atlantic Fishery Management Council. (MAFMC). 1999. Amendment 12 to the summer flounder, scup, and black sea bass fishery management plan. Dover, DE. 398 p + appendix.

Northeast Fisheries Science Center (NEFSC). 2017. 62th Northeast Regional Stock Assessment Workshop (62th SAW) Assessment Report. US Dept Commerce, Northeast Fish Sci Cent Ref Doc. 17-03; 822 p.

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

Table A1. Summary Black Sea Bass assessment results; Spawning Stock Biomass (SSB) in metric tons (mt); Recruitment (R) at age 1 in millions; Fishing Mortality (F) for age of peak fishery selection, ages 6-7. North-South averages, unadjusted for retrospective bias.

	SSB	R	F
1989	2,945	24,489	1.14
1990	2,822	29,922	1.08
1991	2,879	34,458	1.01
1992	3,169	29,266	0.92
1993	3,217	20,098	1.05
1994	3,237	28,754	0.84
1995	3,800	36,967	0.72
1996	4,045	26,625	0.92
1997	3,876	27,269	0.84
1998	4,362	23,149	0.60
1999	5,582	37,771	0.54
2000	7,195	47,726	0.54
2001	9,217	27,700	0.63
2002	9,683	32,088	0.65
2003	9,250	19,804	0.57
2004	7,995	15,685	0.57
2005	7,535	16,988	0.51
2006	6,278	31,800	0.54
2007	6,619	35,909	0.55
2008	9,521	46,010	0.48
2009	11,137	36,055	0.65
2010	14,366	35,934	0.73
2011	14,516	42,838	0.40
2012	17,483	170,362	0.58
2013	26,244	54,782	0.54
2014	40,228	30,553	0.40
2015	39,495	39,629	0.30
2016	37,120	93,799	0.33
2017	31,976	51,186	0.51
2018	27,838	14,872	0.36
2019	18,866	46,198	0.48

Table A2. Total catch (metric tons) of black sea bass from Maine through North Carolina. Includes the 'New' MRIP estimates of recreational catch. Recreational discards assume 15% mortality.

|	Commercial Landings	Commercial Discards	Recreational Landings	Recreational Discards	Total
1989	1,105	109	1,881	99	3,194
1990	1,402	53	1,354	231	3,040
1991	1,190	10	1,766	175	3,142
1992	1,264	141	1,344	165	2,914
1993	1,353	78	2,022	120	3,573
1994	848	37	1,347	210	2,443
1995	889	24	1,860	397	3,171
1996	1,448	285	2,755	236	4,724
1997	1,197	55	2,470	251	3,973
1998	1,152	121	681	310	2,263
1999	1,290	45	856	545	2,736
2000	1,186	44	1,836	873	3,939
2001	1,279	240	2,621	886	5,025
2002	1,564	46	2,528	1,381	5,518
2003	1,347	114	2,492	641	4,595
2004	1,405	380	1,362	374	3,521
2005	1,297	89	1,437	350	3,173
2006	1,285	33	1,243	371	2,933
2007	1,037	104	1,425	354	2,920
2008	875	66	1,606	585	3,132
2009	523	167	2,525	623	3,838
2010	751	134	3,502	733	5,121
2011	765	227	1,421	358	2,771
2012	782	116	3,162	1,048	5,108
2013	1,027	278	2,685	749	4,739
2014	1,088	459	3,510	839	5,896
2015	1,113	423	4,448	985	6,969
2016	1,133	757	6,131	1,391	9,412
2017	1,808	1,027	5,692	1,634	10,162
2018	1,514	722	4,008	1,033	7,277
2019	1,579	1,027	3,914	1,468	7,988
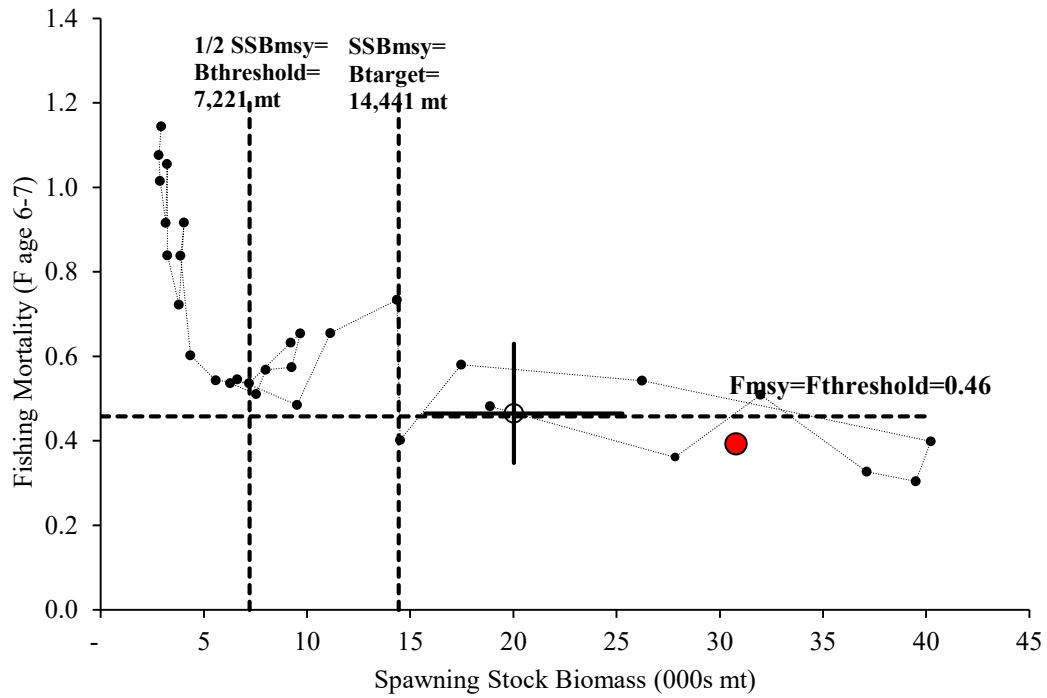
Figure A1. Estimates of black sea bass spawning stock biomass (SSB) and fully-recruited fishing mortality (F, peak at ages 6-7) relative to the updated 2021 biological reference points. Open circle with 90% confidence intervals shows the assessment point estimates. The filled circle shows the retrospectively adjusted estimates.
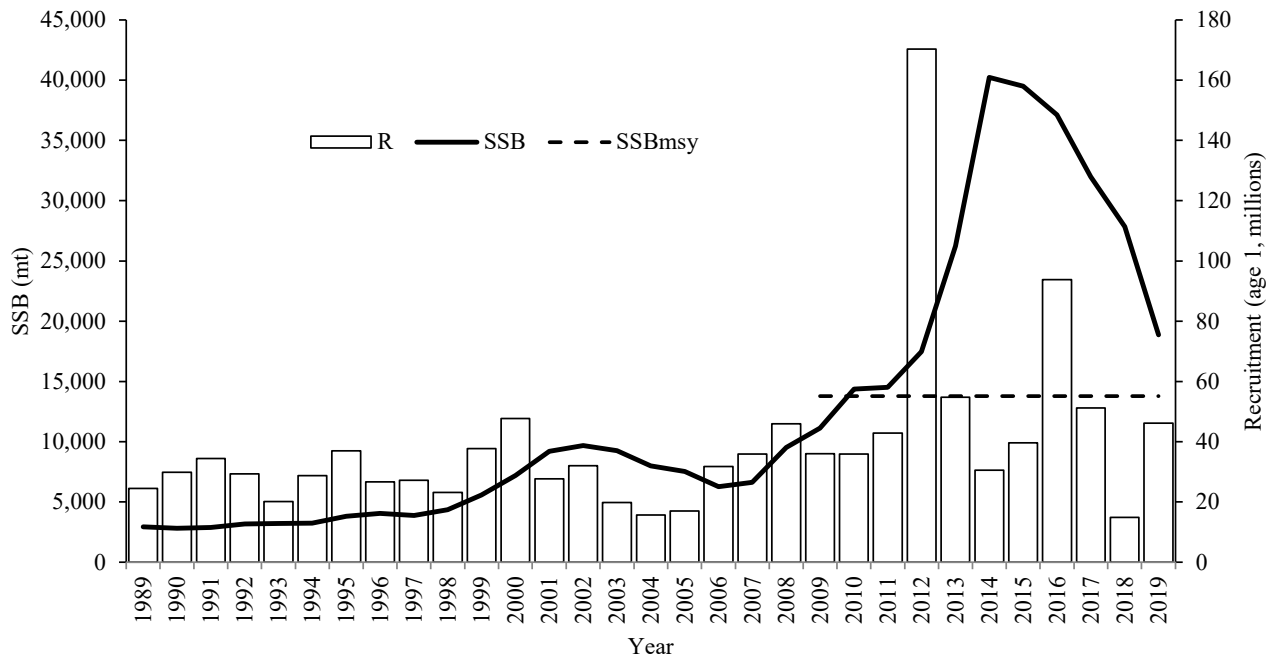
Figure A2. Black sea bass spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year. The horizontal dashed line is the updated SSB_{MSY} proxy = $SSB_{40\%}$ = 14,441 mt.
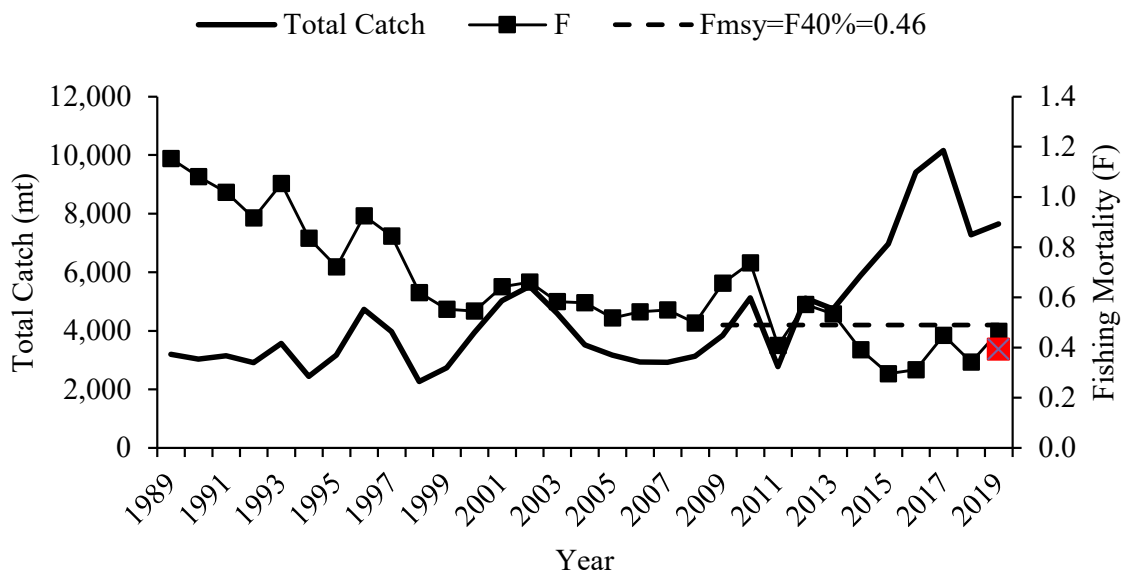
Figure A3. Total fishery catch (metric tons; mt; solid line) and fishing mortality (F, peak at age 6-7; squares) for black sea bass. The horizontal dashed line is the updated F_{MSY} proxy = $F_{40\%}$ = 0.46.
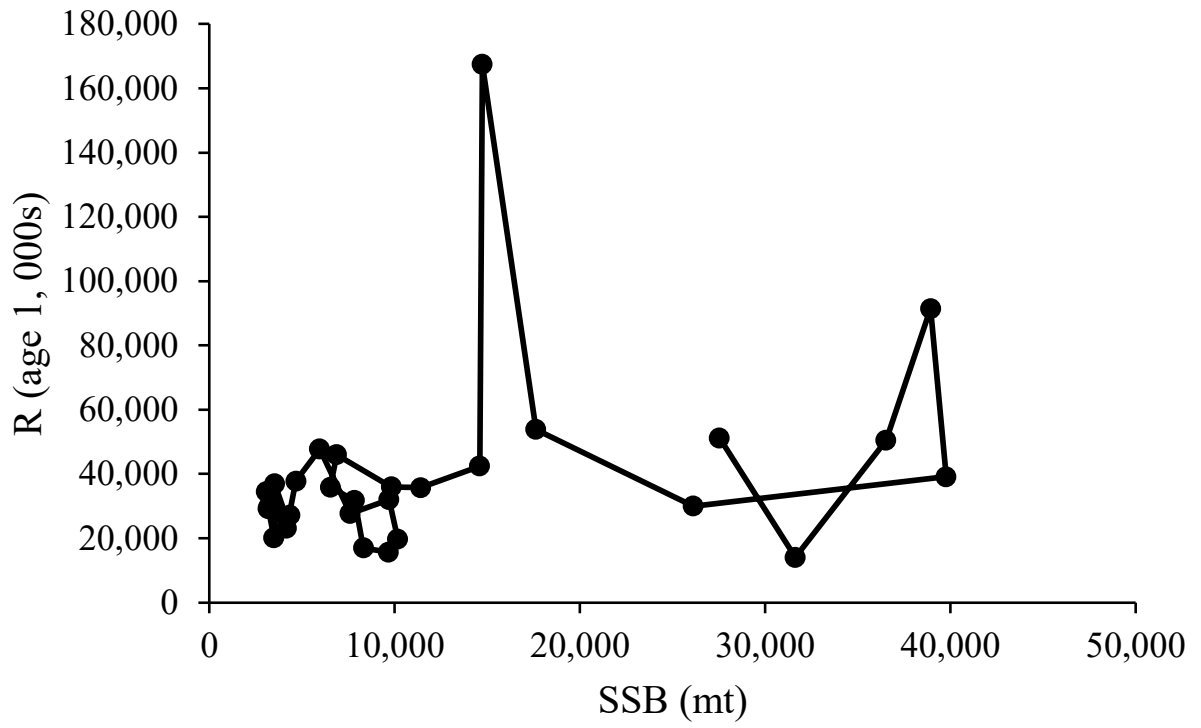
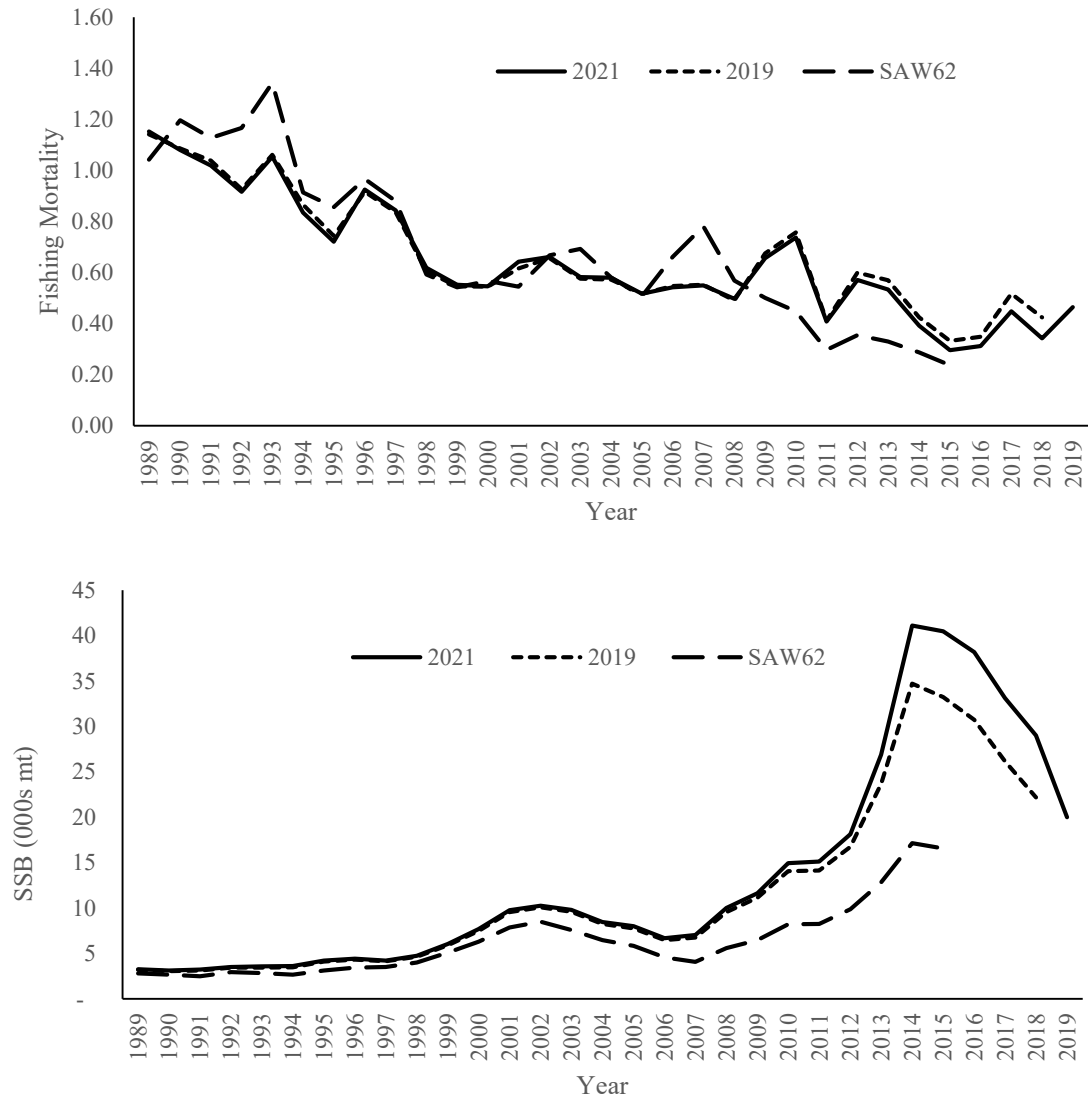Figure A4. Spawning Stock Biomass (SSB) and Recruitment (R) scatter plot for black sea bass.

Figure A5. Historical retrospective of the 2016 (SAW 62; NEFSC 2017), 2019 and 2021 (Operational Assessment) stock assessments of black sea bass. The heavy solid lines are the 2021 Operational Assessment estimates. SAW62 did not include revised MRIP estimates.