Atlantic States Marine Fisheries Commission

Tautog Regional Stock Assessment Update 2021

Vision: Sustainably Managing Atlantic Coastal Fisheries

Atlantic States Marine Fisheries Commission

Tautog Regional Stock Assessment Update

Prepared by the
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EXECUTIVE SUMMARY

This stock assessment is an update to the existing benchmark assessment for tautog (ASMFC 2015, ASMFC 2016); the previous assessment update was completed in 2017 (ASMFC 2017). This assessment updates the accepted statistical catch-at-age model for each region with commercial and recreational fishery catch data and indices of relative abundance from fishery-independent and fishery-dependent data sources through the terminal year of 2020.

Stock status in 2020 varied by region but was generally improved from the 2016 update. In the Massachusetts-Rhode Island (MARI) region, the Long Island Sound (LIS) region, and the Delaware-Maryland-Virginia (DMV) region, the stock was not overfished and overfishing was not occurring. In the New Jersey-New York Bight (NJ-NYB) region, overfishing was not occurring, but the stock was overfished, although spawning stock biomass (SSB) had increased since the previous update and was just below the SSB threshold.

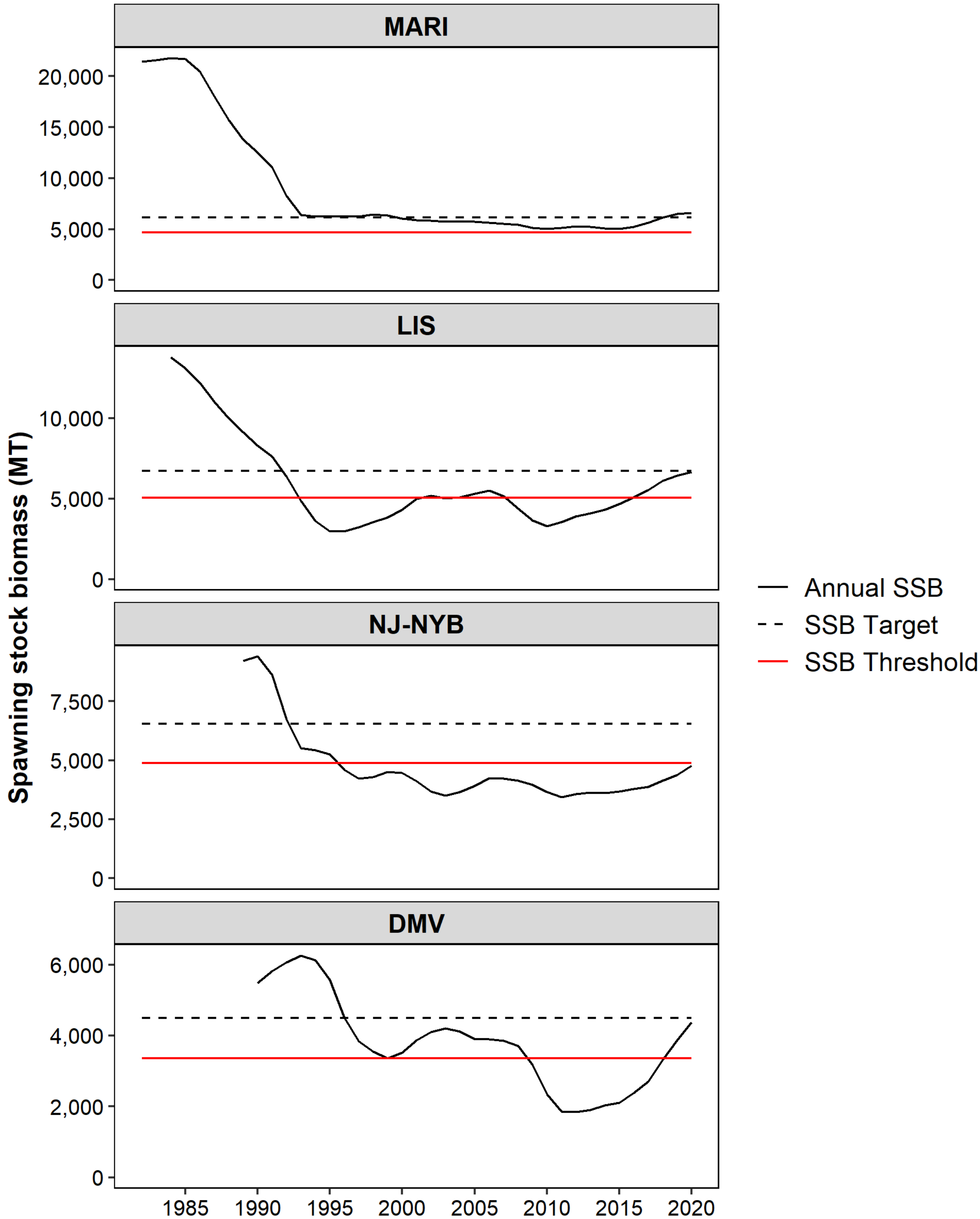
	Spawning Stock Biomass			
Region	**Target**	**Threshold**	**2020**	**Status**
MARI	5,763 mt	4,335 mt	6,568 mt	Not overfished
LIS	6,725 mt	5,044 mt	6,665 mt	Not overfished
NJ-NYB	6,552 mt	4,890 mt	4,782 mt	Overfished
DMV	4,488 mt	3,355 mt	4,396 mt	Not overfished

	Fishing Mortality			
Region	**Target**	**Threshold**	**2020**	**Status**
MARI	0.28	0.49	0.23	Not overfishing
LIS	0.26	0.38	0.30	Not overfishing
NJ-NYB	0.19	0.30	0.26	Not overfishing
DMV	0.17	0.27	0.06	Not overfishing

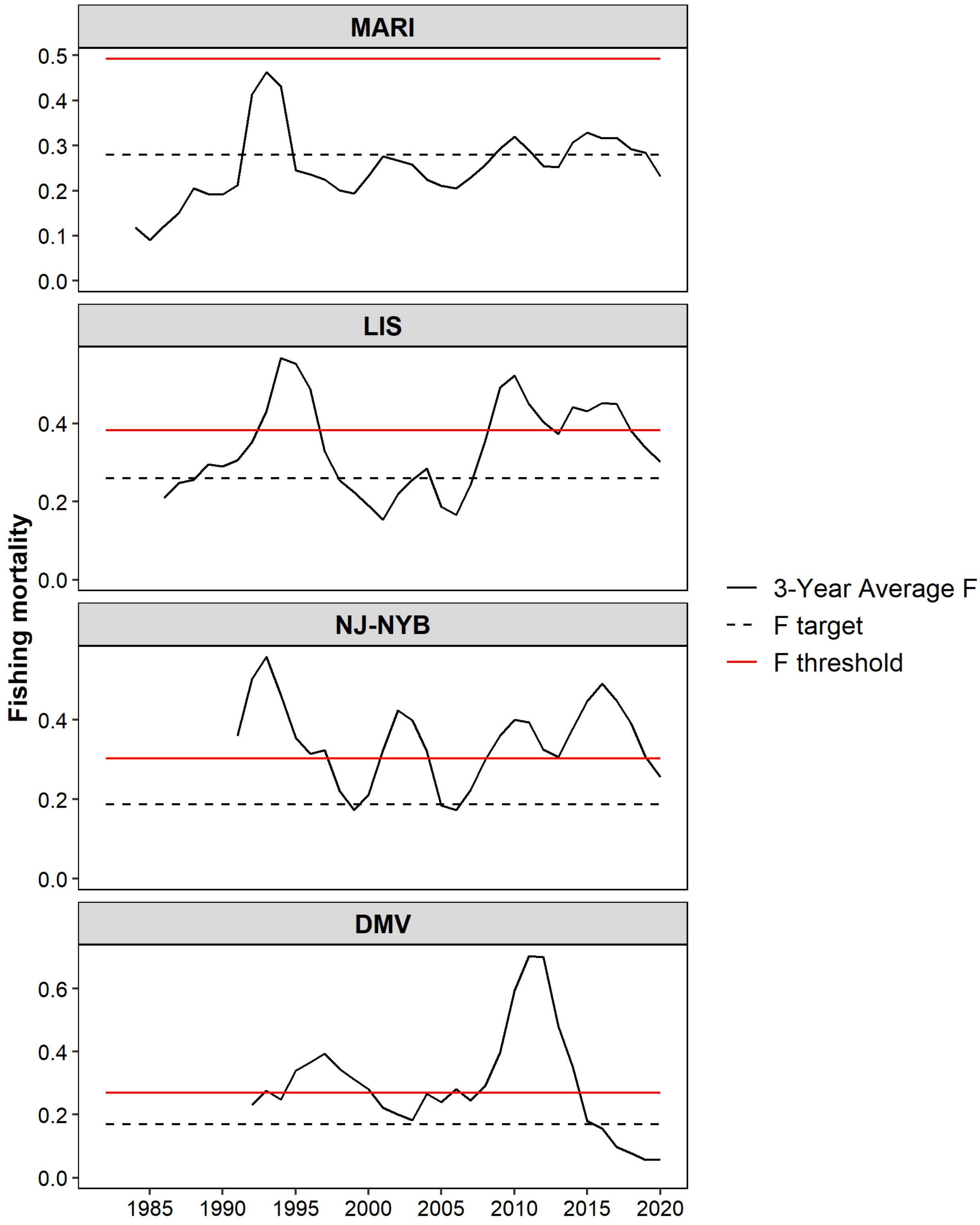
This update included the new time-series of calibrated recreational data from the Marine Recreational Information Program (MRIP). For all regions, the calibrated MRIP estimates of recreational removals was higher across the entire time series than the uncalibrated estimates. For the MARI region, the calibrated estimates averaged 163% higher than the uncalibrated estimates over the time series. For the LIS region, the calibrated estimates averaged 143% higher than the uncalibrated estimates over the time series. For the NJ-NYB region, the calibrated estimates averaged 133% higher than the uncalibrated estimates over the entire time series. For the DMV region, the calibrated estimates averaged 138% higher than the uncalibrated estimates over the entire time series. Like many species, the differences were greater in more recent years. However, for tautog, all regions also saw significantly higher estimates of calibrated catch early in the time series.

The new MRIP estimates resulted in higher estimates of SSB and recruitment in all regions, but had less of an impact on fishing mortality (*F*). Stock status has changed in 3 of the 4 regions since the last assessment update: LIS and DMV are no longer overfished or experiencing overfishing, and NJ-NYB is still overfished but not experiencing overfishing. This appears to be related to reductions in *F* and increases in SSB in the most recent few years, as opposed to an artifact of the new MRIP numbers. Regional stock status in 2015 was the same in the 2021 update as it was in the 2016 update.

All regions showed retrospective patterns in *F* and SSB, with MARI, LIS, and NJ-NYB overestimating *F* and underestimating SSB, while the pattern was reversed in the DMV region. The terminal year values of *F* and SSB were still within the confidence intervals of the model estimates and stock status did not change if the retrospective bias was corrected for, so a retrospective adjustment was not performed. However, the SAS highlighted this as a source of uncertainty in the assessment and recommended that this issue be addressed during the next benchmark.



Spawning stock biomass plotted with the SSB target and threshold by region for the 2021 tautog assessment update.



Three-year average fishing mortality rate plotted with the *F* target and threshold by region for the 2021 tautog assessment update.

TABLE OF CONTENTS

Tautog Stock Assessment Update
MASSACHUSETTS-RHODE ISLAND REGION
2021

Executive Summary
A catch-at-age model was used to estimate population size and fishing mortality rates during 1982-2020 for the Massachusetts-Rhode Island (MARI) management area. This model did not make structural changes or modifications to the estimation process relative to the 2015 benchmark. In general the only modification was the additional years of data, although historical catch-at-age and removals were updated using newly calibrated MRIP data. Biological reference points for the population were calculated using spawning potential ratio (SPR)-based methods. The comparison of the most recent three year averaged (2018-2020) fishing mortality rate (0.23) to the fishing mortality threshold reference point of 0.49 indicated that the MARI population was not experiencing overfishing. The 2020 spawning stock biomass (6,568 mt) was estimated to be above the spawning stock biomass threshold reference point of 4,335 mt, indicating that the population was not overfished. Model diagnostics indicated some residual patterns, especially in age composition data, as well as moderate retrospective trends. However, these patterns were not deemed substantial enough to compromise use of the model results for management purposes.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.
The time series for commercial and recreational removals was extended from the previous assessment update (ASMFC 2017) through 2020, along with the associated age compositions from both sources. Total commercial landings in weight (mt) from 1982-2020 were retrieved from the ACCSP. Total recreational landings (weight) and releases for the same years were retrieved by querying MRIP estimates. Commercial and recreational harvest data were simply converted from landed pounds to mt for use in the model. Recreational releases (i.e., B2 catch) presented more of a challenge because these estimates are only available in numbers. Total estimated releases were converted to estimated releases-at-length using a combination of American Littoral Society (ALS) volunteer angler discard length data and MRIP headboat discard data (i.e., Type 9). Length frequencies were converted to age frequencies using annual age-length keys, which were developed using data from biological sampling programs. Finally, estimated discarded age frequencies were converted to total weight using observed weight-at-age matrices from biological sampling programs; age-specific totals were summed to derive the total estimated annual discards in weight. These totals were multiplied by the assumed discard mortality rate of 2.5% to derive an estimate for dead discards.

Commercial and recreational catch proportions-at-age depended on the observed size frequency distributions and annual age-length keys, which were calculated using data from biological sampling. Observed recreational landings size composition (Type A) were taken from the MRIP size frequency data. Both unobserved recreational landings (Type B1) and commercial landings were assumed to share the same size composition as the Type A data (commercial size regulations are currently consistent with the recreational limit).

This assessment update used the newly calibrated estimates of recreational removals from MRIP. The calibrated estimates of recreational removals (harvest and dead releases) were consistently higher across the entire time series, averaging about 163% higher than the uncalibrated estimates (Figure 1).

The tautog fishery in the MARI region is predominantly recreational (Table 1, Figure 2). Recreational removals comprised 97% of total removals by weight in the region in 1982 with an average of 91.8% for the time series. Total recreational removals were high but variable at the beginning of the time series, averaging about 1.5 million fish from 1982–1992. Recreational removals declined significantly after that, averaging about 425,000 fish from 1993–2013. Recreational removals from 2018–2020, after the implementation of Amendment 1 to the Tautog FMP, have averaged about 521,000 fish.

Commercial landings showed a similar trend, averaging 221 mt from 1982–1993 before declining rapidly to lower but relatively stable numbers through 2020 (Table 1, Figure 2). Commercial landings averaged 59 mt from 1994–2017, and 52 mt from 2018–2020, under Amendment 1.

The calibrated MRIP length frequencies, together with annual age-length keys developed from biological sampling programs, were used to calculate the age composition of the recreational harvest and used as a proxy for the age composition of the commercial harvest. Data from the MRIP at-sea headboat observer program and the ALS volunteer tagging program were used to calculate the age composition of the recreational release mortality. Ages 4-7 made up the majority of the total removals over the time series (each over 10%; MARI Appendix 1).

The Tautog TC developed a fishery dependent catch-per-unit-effort index of abundance from MRIP recreational survey data, using the same “logical species guilds” from the benchmark assessment to identify tautog trips for the effort component. Only non-imputed intercepts were used to calculate average catch rate – and thus the index – for 2020. The MRIP CPUE index was high and somewhat variable at the beginning of the series before declining through the mid-1990s to lower stable levels throughout the 2000s (Figure 3). 2019 and 2020 showed an uptick in the index.

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The set of fishery-independent indices available in the MARI region consists of the Massachusetts Trawl Survey, the Rhode Island Trawl Survey, and the Rhode Island Seine Survey (Table 2, Figure 3). Age composition information was available for the MA and RI trawl surveys and is shown in Appendix 1. For all indices, statistical model-based standardization of the survey data using generalized linear models was conducted to account for factors that affect tautog catchability.

The MA coastal trawl survey is typically performed in the spring and autumn utilizing a stratified random design. Only the results of the spring survey were used for this assessment. The survey was not conducted in 2020 due to COVID-19 restrictions. The index peaked at the beginning of the time series and was highest in the late 1980s; it declined through the 1990s and remains at low, stable levels (Figure 3).

The RI trawl survey has two components, a seasonal survey with a random stratified design which began in 1979, and a monthly fixed station survey which began in 1990 that is conducted monthly throughout the year. For the tautog stock assessment only the fall segment of the RI trawl survey was used, consistent with the benchmark assessment. The RI trawl survey was conducted as usual in 2020. Like the MADMF trawl survey, the RI trawl survey peaked in the mid- to late 1980s and then declined. There was a small increase in the early 2000s, but the index declined again after that and remains low and stable (Figure 3).

The RI seine survey has operated from 1986 to the present, with a consistent standardized methodology starting in 1988. It is a fixed site survey that takes place throughout the extent of Narragansett Bay Rhode Island. The survey was conducted as usual in 2020. The index was highest during the early 2000s and the late 1980s, and in recent years has been increasing since 2010 with a peak of 13.75 fish/seine in 2019 (Figure 3).

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (M, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised M value) from benchmark.

There were no significant changes to life history information or model structure from the benchmark stock assessment (Table 3).

The update uses data from 1982 – 2020. Natural mortality was fixed at 0.16 across all ages and years, maturity in each year was set at 0 for age 1 and age 2, 0.8 for age 3 and all fish age 4 and older were considered fully mature. All fish aged 12 and greater were grouped together for the assessment (i.e., these fish were represented in the plus group). Release mortality for all age classes in all years remained at 2.5%. Annual weight-at-age was the average weight for each age class, weighted by the abundance-at-size within each age class – in other words changes in size-at-age would be reflected in the annual average weight-at-age matrix.

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

The ASAP (Age Structured Assessment Program) model from the NOAA Fisheries Toolbox was used to estimate population fishing mortality, abundance, recruitment trends and other parameters and states. The primary model used in this assessment was an update of the 2015 benchmark assessment that used data through 2020; the major difference was the use of recalibrated MRIP data. A bridge model was produced for comparison using the newly calibrated data but with a terminal year of 2015 to align with the terminal year of the 2016 update. Further sensitivity runs included (1) exclusion of MA trawl survey; (2) exclusion of RI trawl survey; (3) exclusion of RI seine survey; (4) exclusion of MRIP index; (5) alternate MRIP index using imputed 2020 data; and (6) survey CVs unadjusted for optimizing diagnostic root mean standard errors (RMSE). Retrospective runs (seven peels) were produced for the base model to address coherence in annual estimates.

The stock assessment model was able to successfully estimate fishing mortality and spawning stock biomass for the MARI tautog population through 2020. The final maximum gradient, a measure indicating the stability of the model that should be close to zero, was 0.00086. There were residual patterns evident in diagnostic plots, especially for age compositions associated with abundance indices as well as catch (see MARI Appendix 1); however, these patterns were not deemed substantial enough to compromise use of the model results for management purposes. The model estimates tracked the general pattern of observations in the MA and RI trawl surveys as well as the MRIP CPUE annual indices, but did not closely follow observations for the RI seine survey.

A bridge model was run to isolate the impact on the assessment estimates of updating MRIP removals using calibrated data from the effect of adding additional years of data. The bridge run did not make any additional adjustments to the model structure; the new MRIP AB1 landed weight and B2 numbers converted to dead discard weight as well as updated catch-at-age proportions were inserted into the model files in place of the catch-at-age and landings that were used in the 2016 update assessment. The new MRIP estimates approximately doubled estimates of SSB and recruitment (Figure 4 and Figure 5). The update assessment did not change the overall scale of fishing mortality (Figure 6) because the model estimated a larger population size to account for the larger removals. The calibrated MRIP data did result in a spike in fishing mortality during 1992 that was not consistent with the 2016 update. In addition, the final *F* estimate for 2015 was approximately double that estimated during the 2016 update, but adding 2016-2020 data lowered the estimate of *F* for 2015. This was consistent with the retrospective pattern noted for the base run of the current update.

Retrospective errors were evident for *F* (Mohn's rho = 0.37), SSB (Mohn's rho = -0.10) and recruitment (Mohn's rho = -0.16). Fishing mortality estimates tended to be overestimated relative to the terminal year run and be revised down with additional years of data (Figure 7) while SSB estimates (Figure 8) tended to be underestimated and revised up with additional years of data. Recruitment revisions (Figure 9) were mixed. The retrospective bias was still within the confidence intervals of the terminal year estimates of *F* and SSB, so a retrospective adjustment was not conducted (MARI Appendix 2 Figure A2.1). The source of retrospective patterns was unknown. Retrospective runs on sensitivity analyses did not indicate that tension among survey indices was a source of retrospective patterns.

There were no obvious trends in fishing mortality over the time series – in general it ranged between 0.07 and 0.37, save for a spike to 0.77 during 1992 (Table 4, Figure 10). Estimated spawning stock biomass (Figure 10) generally reflected the trend in removals (Figure 2) and in the MA and RI trawl indices and MRIP CPUE index (Figure 3) with the highest estimates occurring early in the time series during the 1980s followed by a substantial decline to lower levels where the stock has generally remained since the early 1990s (Table 4, Figure 10). The estimates suggest a small increase in spawner biomass since 2016. The model estimated recruitment has remained generally stable throughout the time series (Table 4, Figure 5), without the dramatic fluctuations that characterize some fish populations. The highest estimated recruitment occurred in 1982 during the period of highest spawner biomass, but the second highest recruitment event occurred in 2015 during a period of relatively low biomass.

Six sensitivity runs were produced to examine the dependence of the model results on the four survey indices, the 2020 MRIP data imputation methods, and survey index CVs that were unadjusted to correct for RMSE (MARI Appendix 2 Figures A2.2 and A2.3). No sensitivity run substantially changed the general trends in fishing mortality or SSB over the time series. The largest average percent difference in *F* was 14% and occurred when the MA trawl survey was removed; however, the largest median difference was only 2% and occurred when the MRIP index was removed. The largest percent differences in SSB occurred when the MA trawl survey and MRIP index were removed, both causing estimates averaging 7% larger than the base model. The largest median percent difference occurred when the 2020 imputed data were used, causing estimates that were 7% lower than the base model.

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

The target and threshold levels for fishing mortality were calculated using spawning potential ratio (SPR) reference points. The previous assessment update recommended use of maximum sustainable yield (MSY) reference points, but ultimately SPR reference points were used for management purposes. The updated target fishing mortality reference point for 2021, F40%, was 0.28 and the threshold level, F30%, was 0.49, the same values as estimated for the 2016 update (Table 5). The three-year average (i.e., 2018-2020) Fishing Mortality was estimated to be 0.23. Since the three-year average fishing mortality was below the target and threshold, the model did not indicate that overfishing was occurring (Table 6, Figure 10).

Target and threshold SSB reference points were calculated by determining equilibrium SSB when assuming fishing at the target or threshold fishing mortality levels and assuming historical recruitment patterns as well as terminal year selectivity, maturity and weight-at-age. These calculations were conducted using the AgePro program from the NOAA Fisheries Toolbox. The SSB threshold was 4,335 mt and the SSB target was 5,763 mt, higher than the estimates from the 2016 update (Table 5). Estimated 2020 SBB was 6,568 mt. Since the estimated spawner biomass was above both the target and the threshold, the model indicated that the stock was not overfished (Table 6, Figure 10).

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

Short term projections were implemented to estimate the probability of overfishing or the stock being overfished during 2022-2025. Projections assumed a harvest level equal to the average annual removals during 2018-2020 (941 mt). Stock life history information and selectivity patterns were assumed equal to the terminal model year (i.e., the current patterns persisted throughout the projection period). During each projection instance, recruitment was drawn randomly from the empirical distribution of recruitments previously estimated by the ASAP model. Under these assumptions, the short term projections showed a 100% probability of being at or below the F target in 3 years and showed a 100% probability of being at or above the SSB threshold in 3 years (Table 7, Figure 11).

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

Fishery-dependent high priorities from the last benchmark assessment focused on biological sampling. A need for expanded sampling of commercial catch, continuation of collecting age structures, increasing catch and discard lengths from commercial and recreational fisheries, and an increase in MRIP sampling to improve recreational catch estimates.

The MARI region has continued to collect age structures since the benchmark, and has on the recommendation of the TC begun collecting paired samples of opercula and pelvic spines (RI) or otoliths (MA). One difficulty with collecting opercula or otoliths from the commercial fishery is the presence of the live market and the whole fish market. If the pelvic spine is deemed an appropriate structure by the aging committee, use of spines as the primary age structure collected should allow for increased samples. This is a diversion from the benchmark which suggested taking paired otolith samples to compare to opercula. While RI (and MA) did sample both opercula and otoliths, the presence of the live and whole fish market is driving the need for a non-lethal and non-mutilating method of collecting age structures. In addition, the assessment process identified differences in length-at-age between Massachusetts and Rhode Island. These differences may be naturally occurring or the result of differences in ageing techniques. This should be pursued and the source of the disparity identified if possible.

Additional improvements to MRIP sampling for tautog should be made. While percent standard error (PSEs) are reasonable for state level landings, improvements of PSEs by mode through additional sampling would greatly increase the understanding of the fishery, especially as tautog is a recreational heavy fishery.

Fishery-independent priorities included conducting a workshop and pilot studies to design a multi-state fishery survey, to establish standardized multi-state surveys to monitor tautog abundance and to develop young of the year (YOY) indices, and to enhance age structure collection for smaller fish.

The RI seine survey is used as the MARI YOY index and has been ongoing since 1988.

Since the benchmark, both RI and MA have sampled fish smaller than 20cm for age/length. Sample sizes continue to be small at this size and sampling should continue to be a priority to improve the age-length key.

List of Appendices

MARI Appendix 1: ASAP plots output of the base model
MARI Appendix 2: Retrospective adjustments and sensitivity runs

References

Atlantic States Marine Fisheries Commission. 2015. Tautog benchmark stock assessment. Arlington, VA.

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Atlantic States Marine Fisheries Commission. 2017. 2016 Tautog Stock Assessment Update. Arlington, VA. 143 pp.

Tables

Table 1. Total removals in metric tons by sector for the MARI region.

Year	Recreational Harvest	Recreational Release Mortalities	Commercial Harvest
1982	2,700.6	2.4	70.6
1983	1,714.1	10.6	90.8
1984	1,761.8	17.9	182.7
1985	603.4	5.9	211.6
1986	4,363.9	21.5	239.9
1987	1,834.5	13.3	304.1
1988	2,905.9	23.0	274.9
1989	1,523.2	8.6	257.1
1990	1,792.2	13.7	226.9
1991	2,502.6	20.3	329.3
1992	4,624.0	12.4	295.8
1993	1,109.0	7.9	164.2
1994	579.8	14.5	76.1
1995	507.1	14.0	59.1
1996	771.0	20.9	44.2
1997	441.9	12.5	47.1
1998	415.7	12.2	50.6
1999	1,033.1	34.8	46.1
2000	903.2	14.0	63.4
2001	655.3	20.0	63.7
2002	788.3	37.6	89.8
2003	868.9	30.0	63.9
2004	818.2	20.1	56.6
2005	1,052.1	29.3	64.5
2006	732.2	28.0	88.4
2007	650.6	26.4	72.2
2008	732.8	22.6	55.3
2009	855.3	34.9	47.9
2010	1,106.9	27.4	54.1
2011	513.7	41.2	47.7
2012	868.9	42.7	53.5
2013	1,571.0	67.6	56.1
2014	1,198.2	104.1	52.9
2015	973.6	72.7	49.4
2016	729.1	55.3	49.3
2017	1,580.3	107.1	54.1
2018	623.8	100.7	51.0
2019	965.8	118.3	51.5
2020	701.3	158.5	52.6

Table 2. Indices used in the ASAP model for the MARI region

Index Name	Index Metric	Design	Time of Year	Years	Ages
MRIP CPUE	Total catch per angler-trip	Stratified Random	Mar-Dec	1982-2020	2+
Massachusetts Trawl Survey	Mean number per tow	Stratified Random	Spring and Fall	1982-2019	2+
Rhode Island Fall Trawl Survey	Mean number per tow	Stratified Random	September - November	1982 - 2020	2+
Rhode Island Narragansett Bay Seine	Mean number per haul	Fixed	June - October	1988-2020	YOY

Table 3. Model structure and life history information used in the MARI stock assessment

	Value(s)
Years in Model	1982-2020
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%
Fraction of year before SSB clculation	0.42
Number of selectivity blocks	3
Selectivity periods	1982-1996, 1997-2006, 2007-2020
Selectivity type	Single logistic

	Age Group											
	1	2	3	4	5	6	7	8	9	10	11	12
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

Table 4. Spawning stock biomass, recruitment, annual F, and 3-year average *F* estimates for the MARI region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual *F*	3-year Average *F*
1982	21,417	3.43	0.15	-
1983	21,557	2.52	0.10	-
1984	21,744	1.91	0.09	0.11
1985	21,683	1.71	0.07	0.09
1986	20,430	1.89	0.20	0.12
1987	18,024	1.91	0.18	0.15
1988	15,697	2.13	0.22	0.20
1989	13,766	1.73	0.16	0.19
1990	12,534	1.65	0.18	0.19
1991	11,048	1.73	0.28	0.21
1992	8,246	1.75	0.75	0.40
1993	6,376	1.65	0.32	0.45
1994	6,214	1.70	0.19	0.42
1995	6,308	1.65	0.20	0.24
1996	6,236	1.41	0.29	0.23
1997	6,229	1.45	0.16	0.22
1998	6,426	1.66	0.14	0.20
1999	6,346	1.86	0.28	0.19
2000	6,026	1.58	0.28	0.23
2001	5,880	1.28	0.27	0.27
2002	5,825	1.32	0.25	0.26
2003	5,733	1.38	0.25	0.26
2004	5,709	1.41	0.17	0.22
2005	5,724	1.62	0.21	0.21
2006	5,610	1.40	0.23	0.20
2007	5,535	1.36	0.24	0.23
2008	5,409	1.83	0.29	0.25
2009	5,155	1.55	0.34	0.29
2010	5,035	1.30	0.31	0.31
2011	5,148	1.42	0.20	0.28
2012	5,290	1.76	0.23	0.25
2013	5,226	1.66	0.31	0.24
2014	5,075	2.10	0.36	0.30
2015	5,016	2.80	0.29	0.32
2016	5,240	2.25	0.27	0.31
2017	5,652	1.44	0.36	0.31
2018	6,140	1.28	0.22	0.28
2019	6,502	1.67	0.25	0.28
2020	6,568	1.41	0.21	0.23

Table 5. SSB and *F* reference points from 2016 and 2021 updates for the MARI region

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
2016 Update	2,684	2,004	0.28	0.49
2021 Update	5,763	4,335	0.28	0.49

Table 6. Stock status for the MARI region.

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
Reference Points	5,763	4,335	0.28	0.49
2020 Value	6,568		0.23	
2020 Status	Not Overfished		Overfishing not Occurring	

Table 7. Short-term projection results for the MARI region using status quo removals.

Landings (mt) for 2022-2025	Probability of being at or below *F* Target in 3 years	Probability of being at or above SSB threshold in 3 years
Status quo (2018-2020 average)	100%	100%

Figures

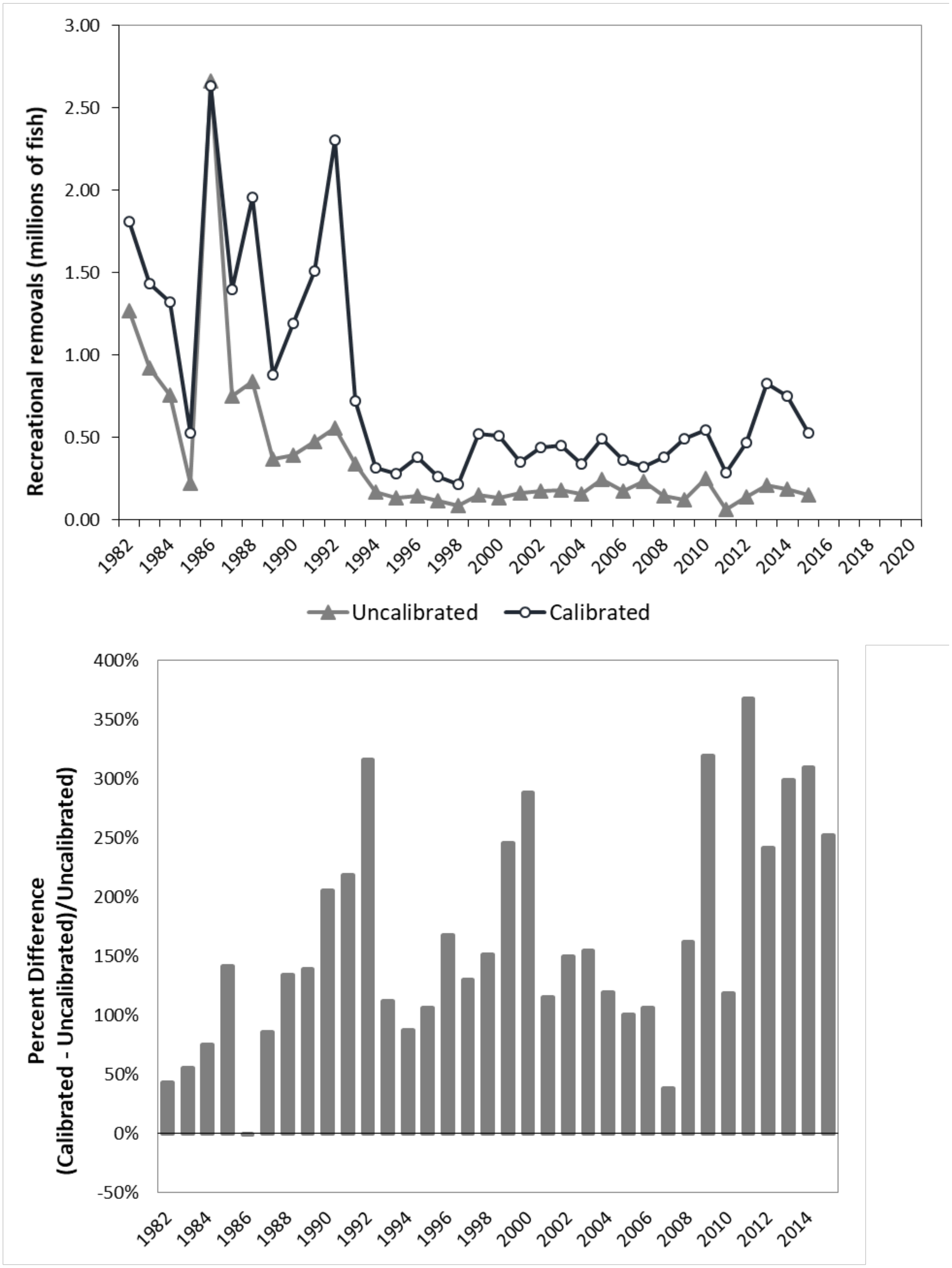


Figure 1. Comparison of calibrated and uncalibrated recreational removals (harvest + dead releases) in numbers of fish (top) and percent difference (bottom) for the MARI region.

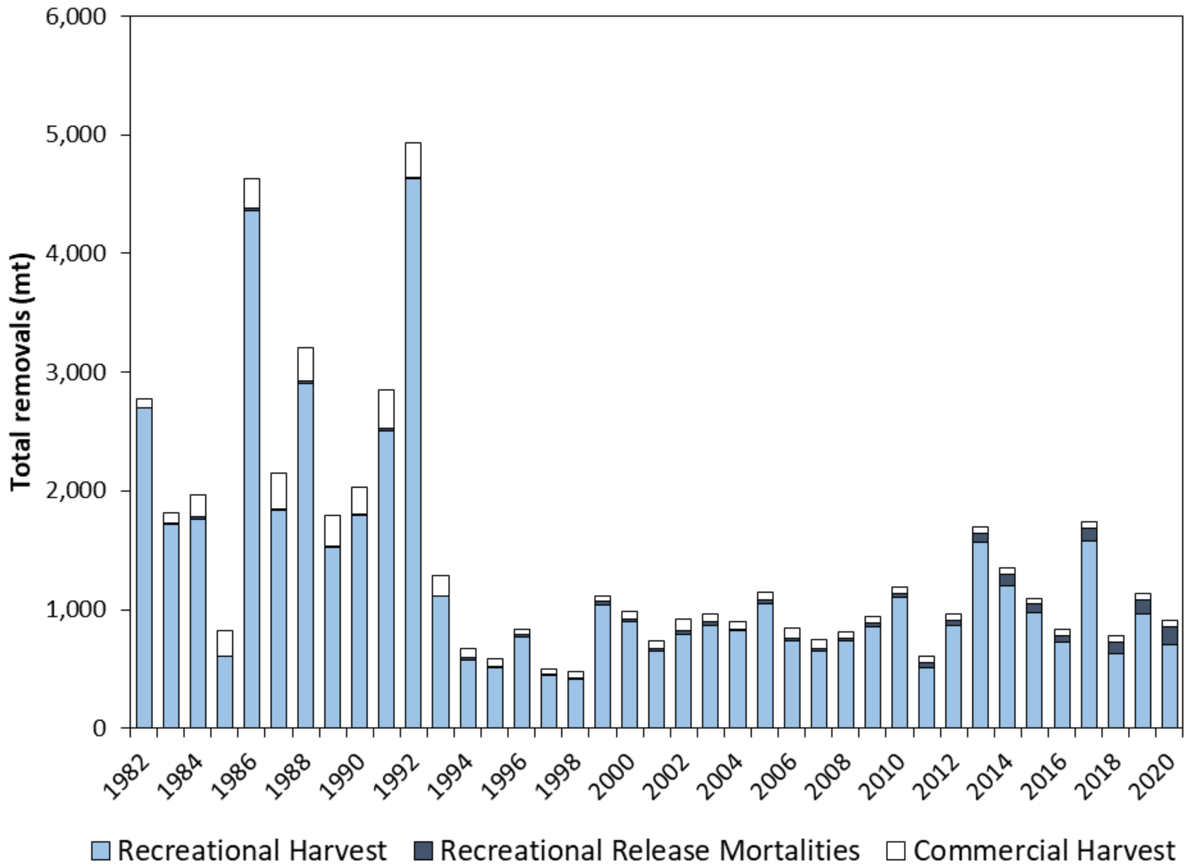


Figure 2. Total removals by sector for the MARI region.

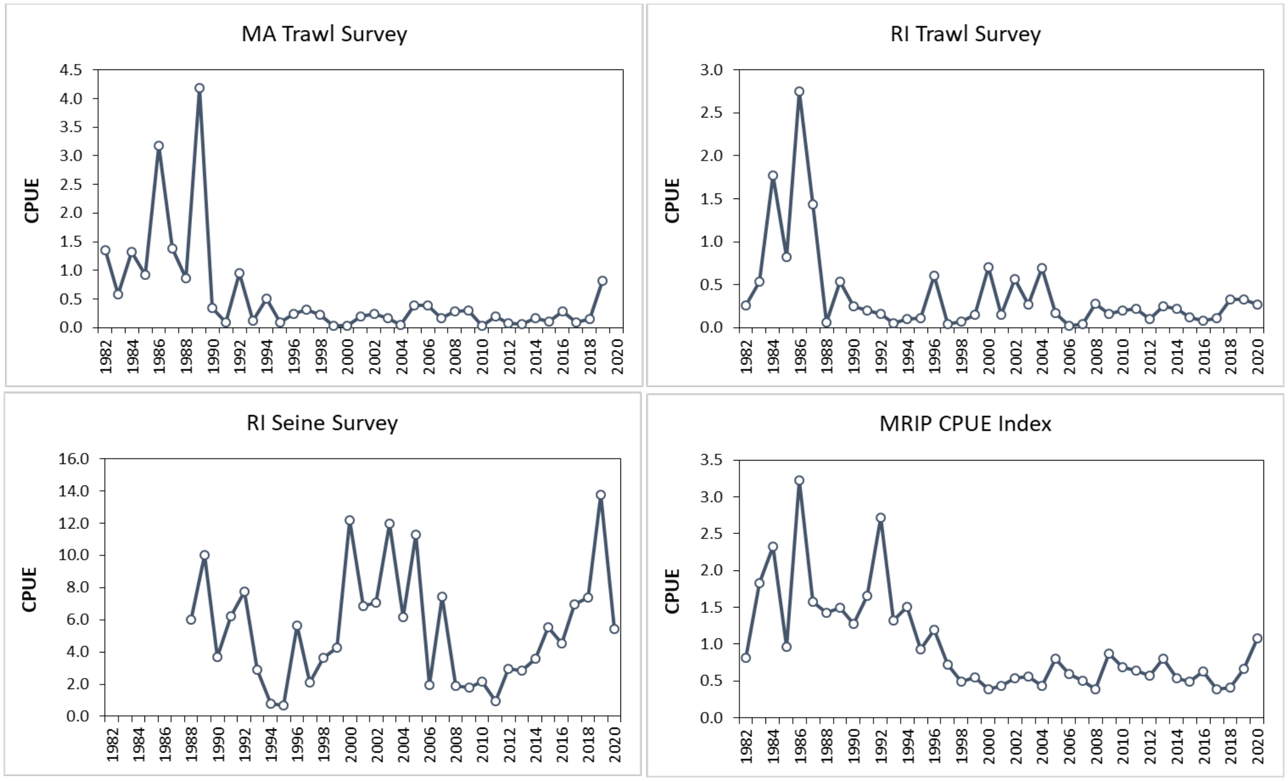


Figure 3. Indices of abundance used in the ASAP model for the MARI region.

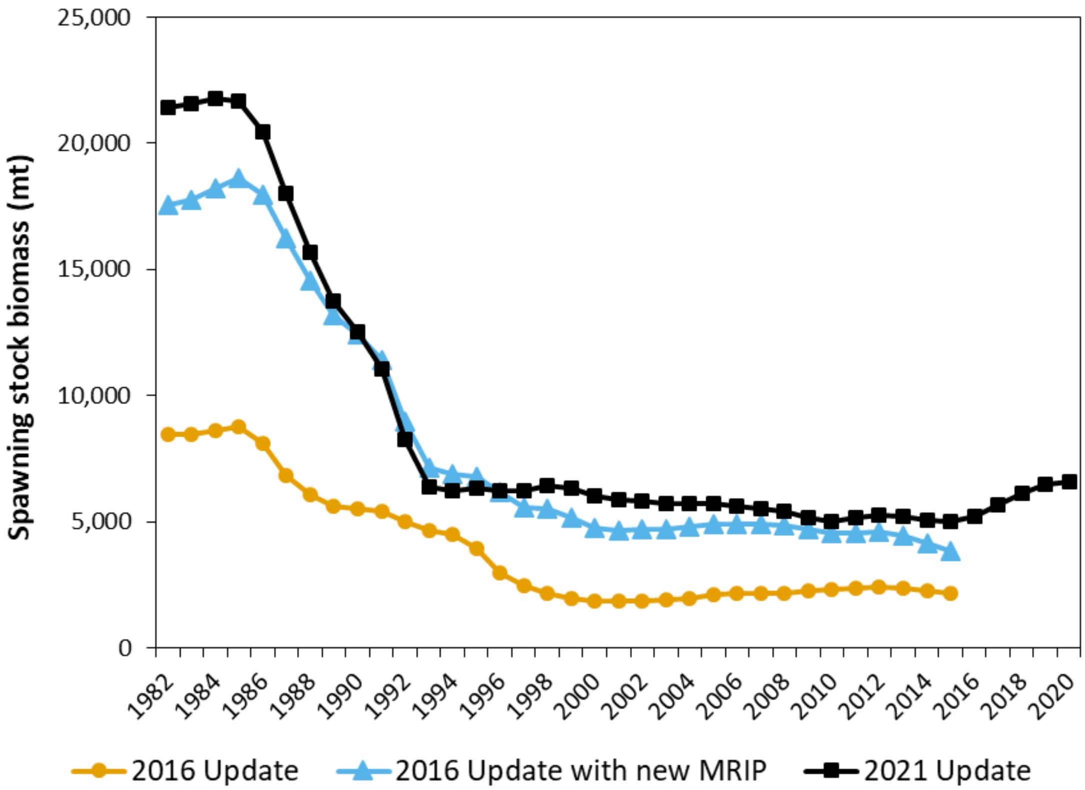


Figure 4. Estimates of spawning stock biomass for the MARI region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

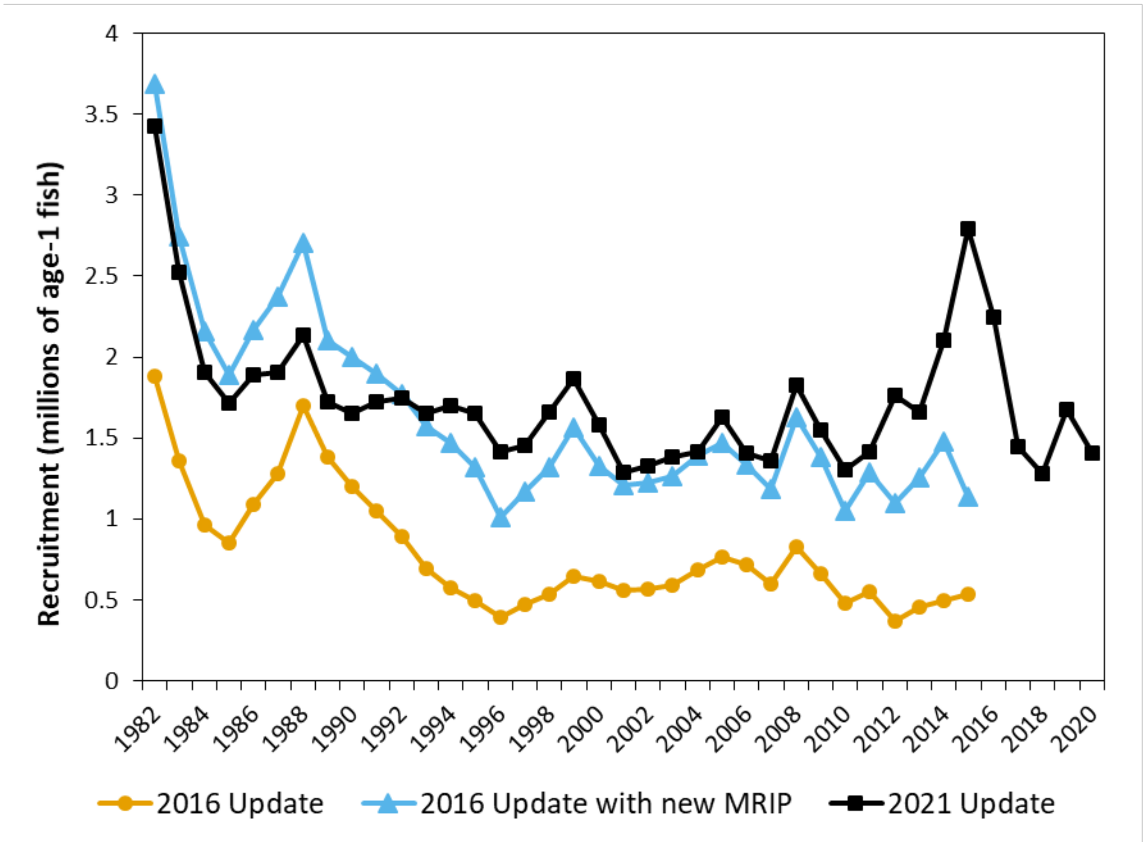


Figure 5. Estimates of recruitment for the MARI region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

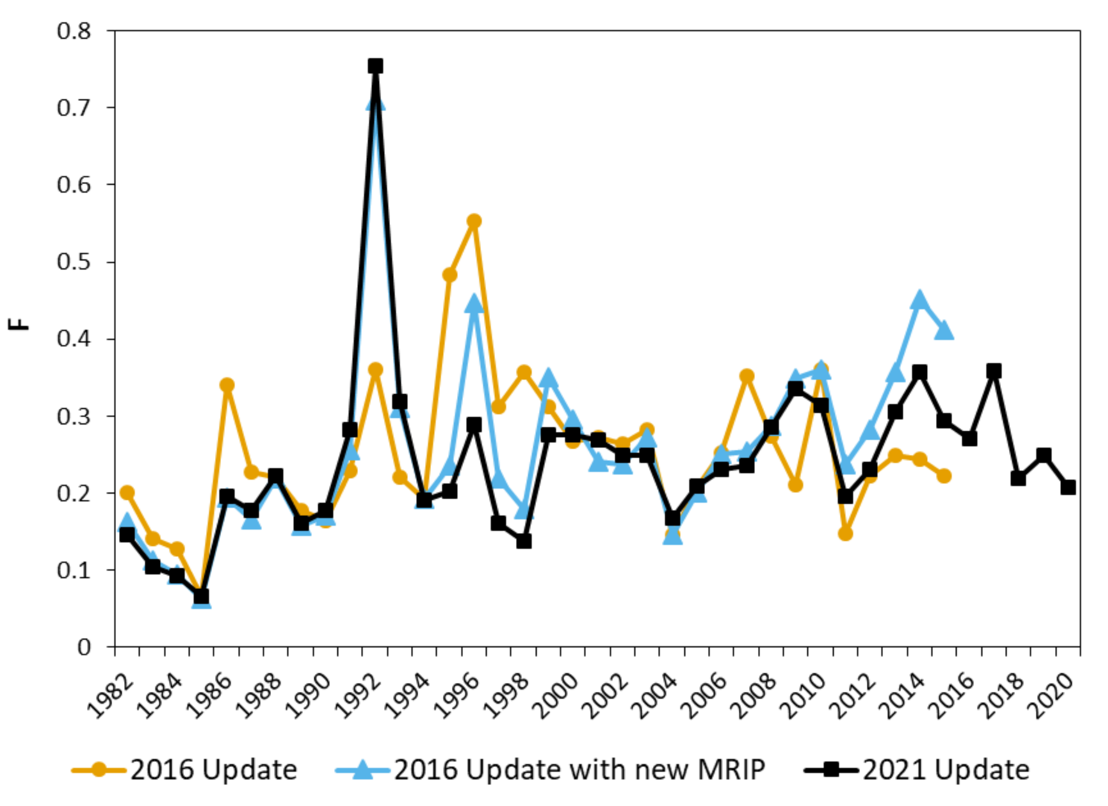
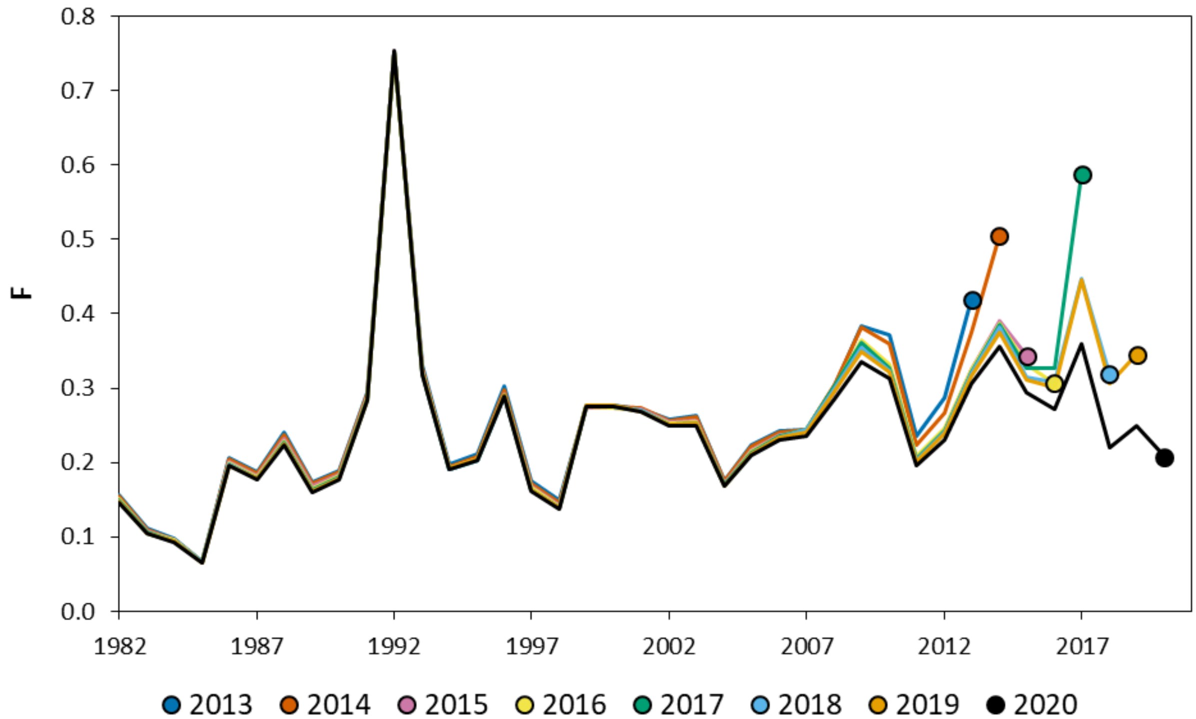


Figure 6. Estimates of the annual full *F* for the MARI region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.



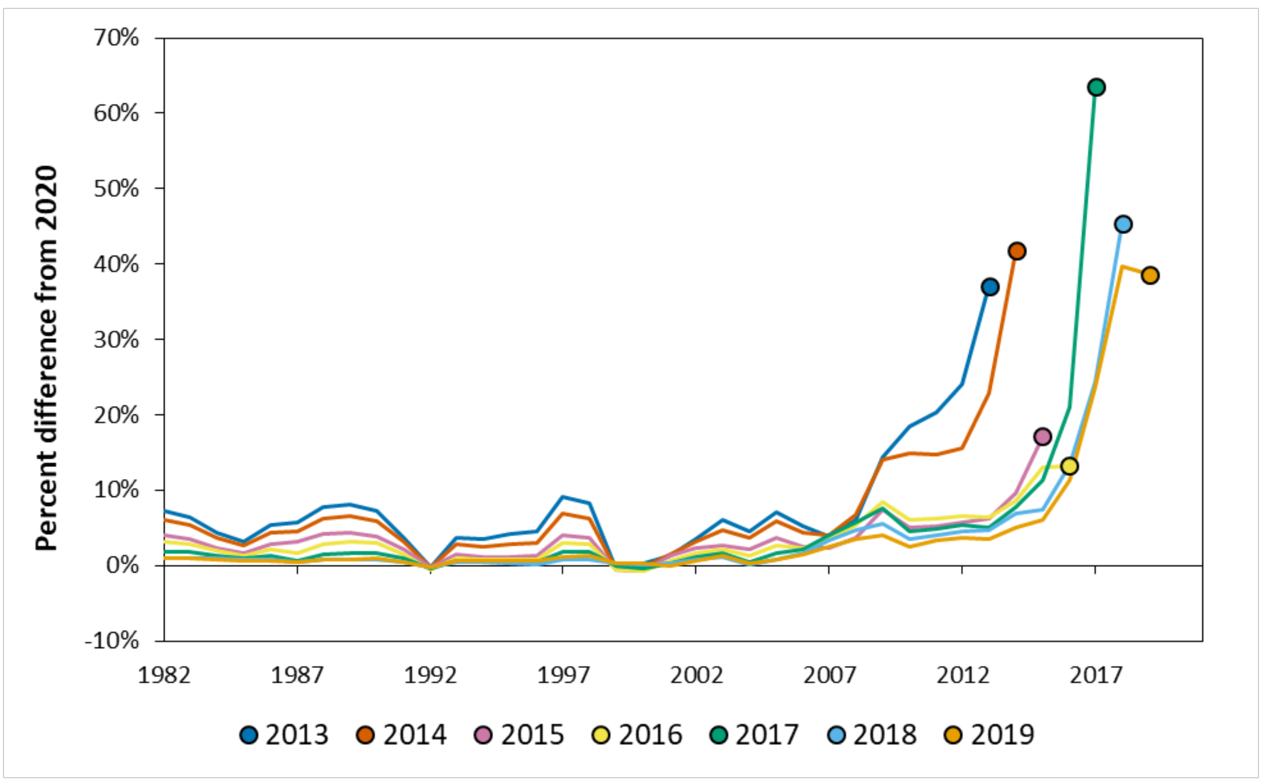
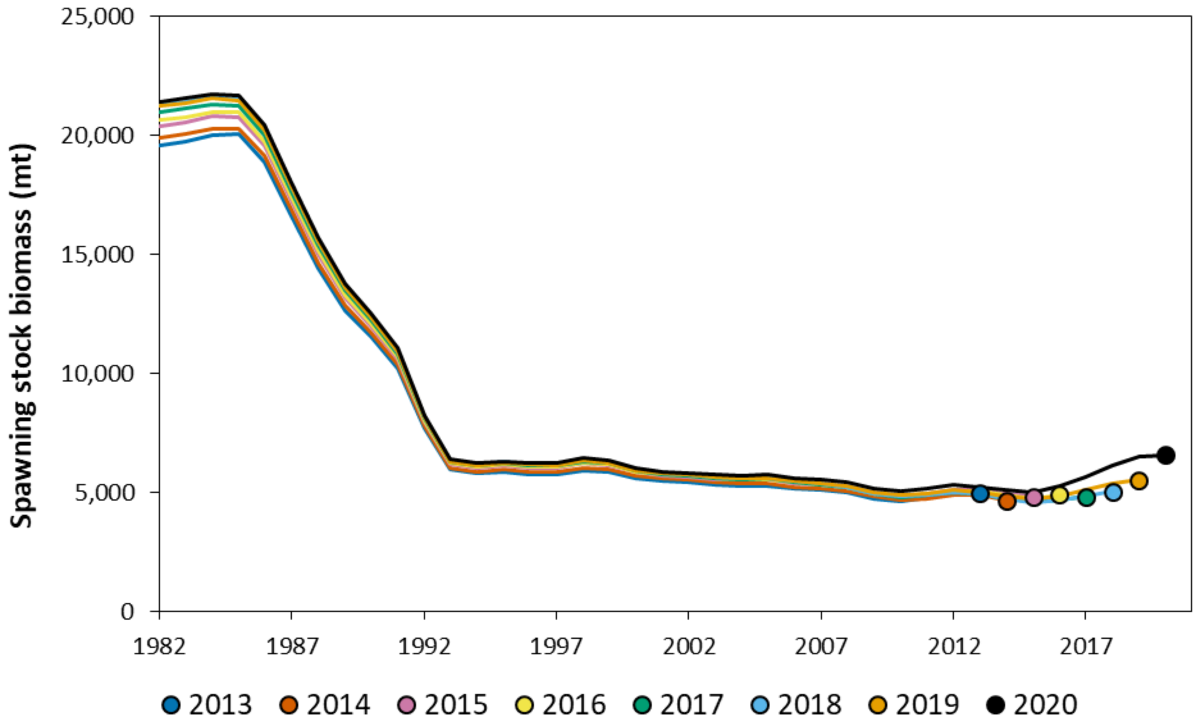


Figure 7. Retrospective analysis for annual *F* for the MARI region in absolute numbers (top) and percent difference (bottom).



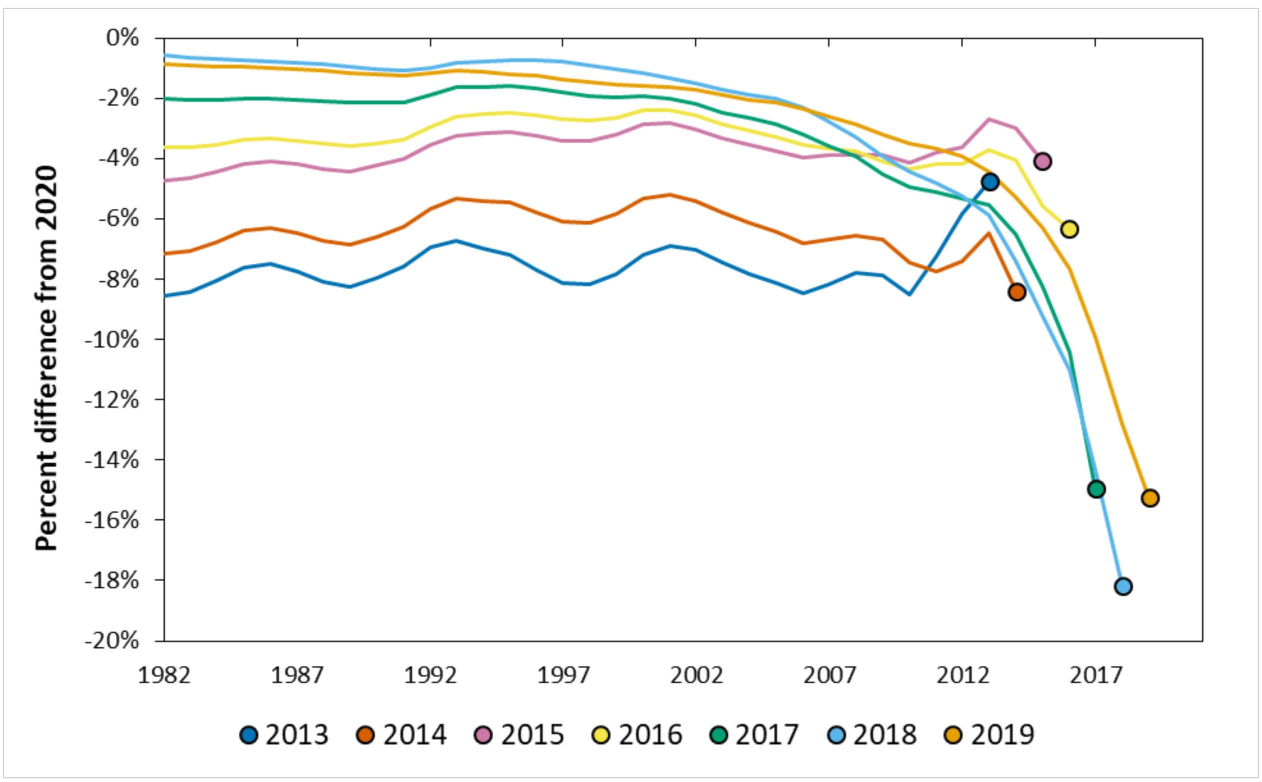
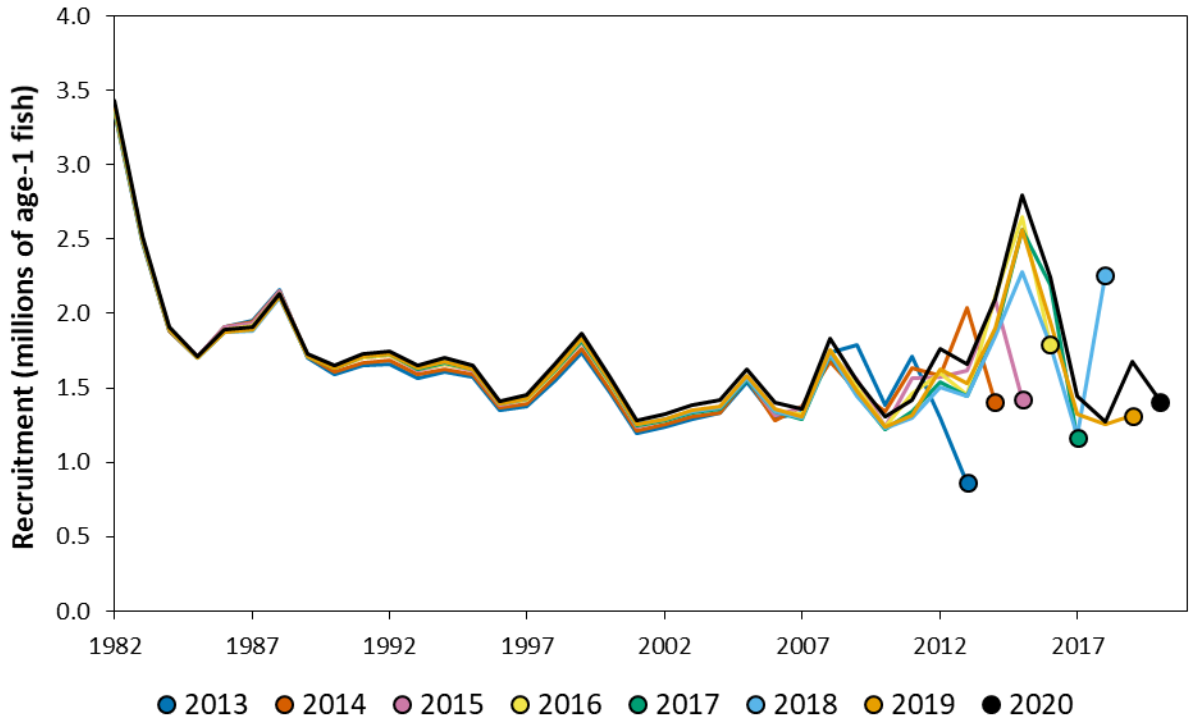


Figure 8. Retrospective analysis for SSB for the MARI region in absolute numbers (top) and percent difference (bottom).



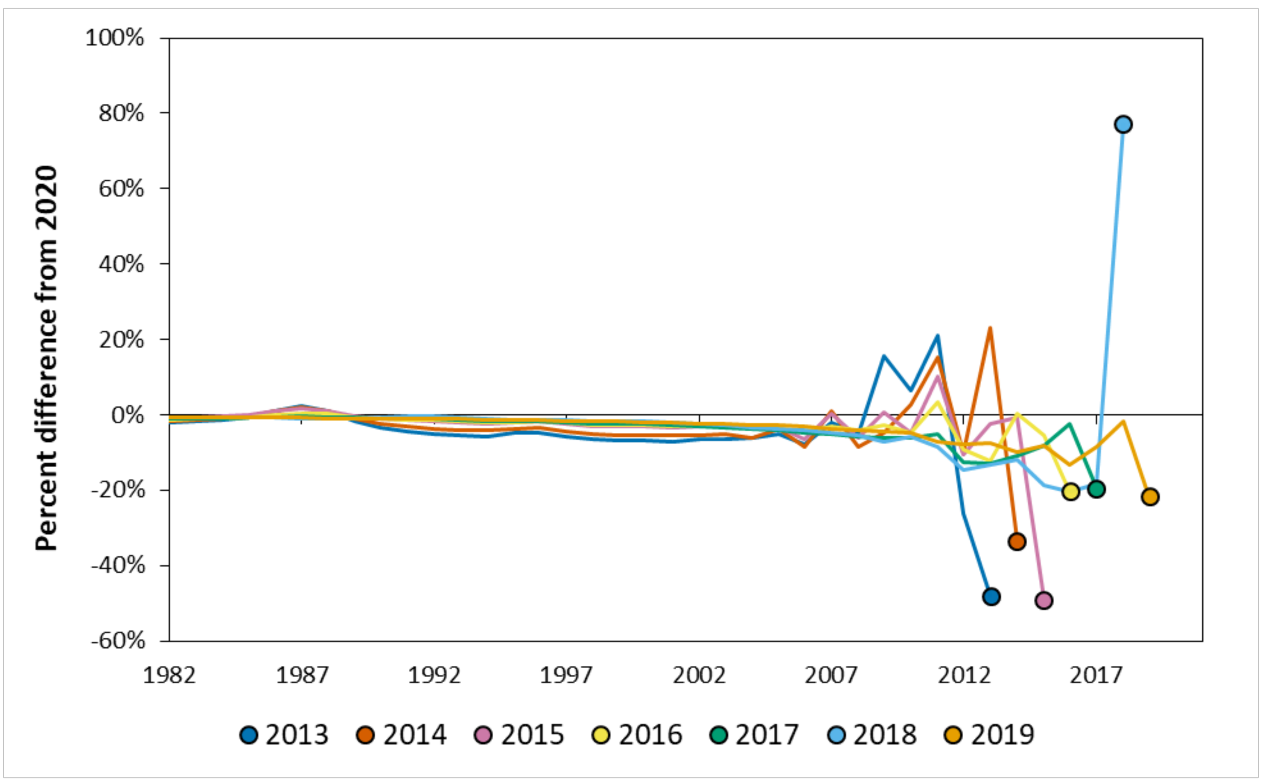


Figure 9. Retrospective analysis for recruitment for the MARI region in absolute numbers (top) and percent difference (bottom).

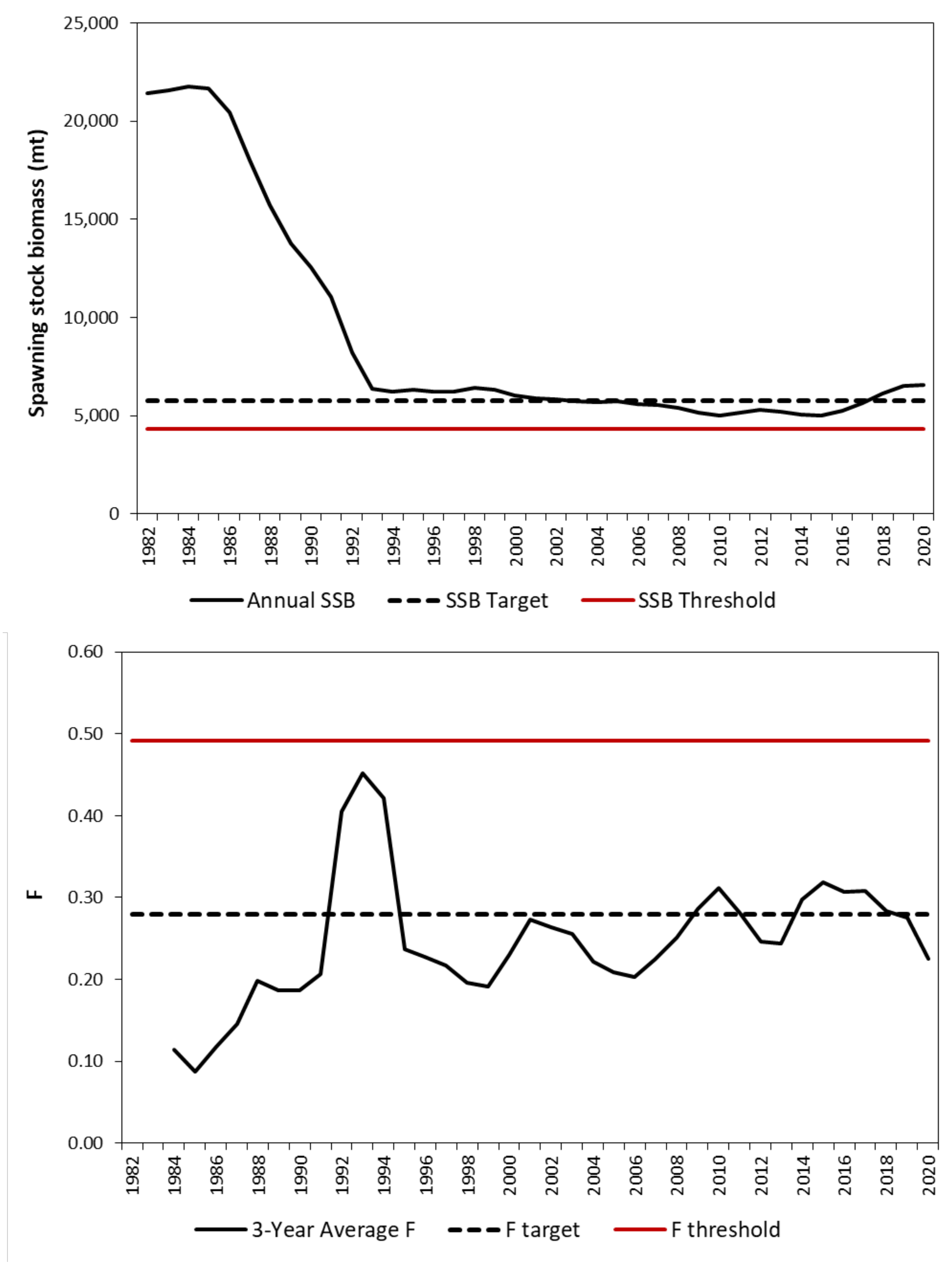


Figure 10. Annual SSB plotted with SSB target and threshold (top) and 3-year average *F* plotted with *F* target and threshold (bottom) for the MARI region.

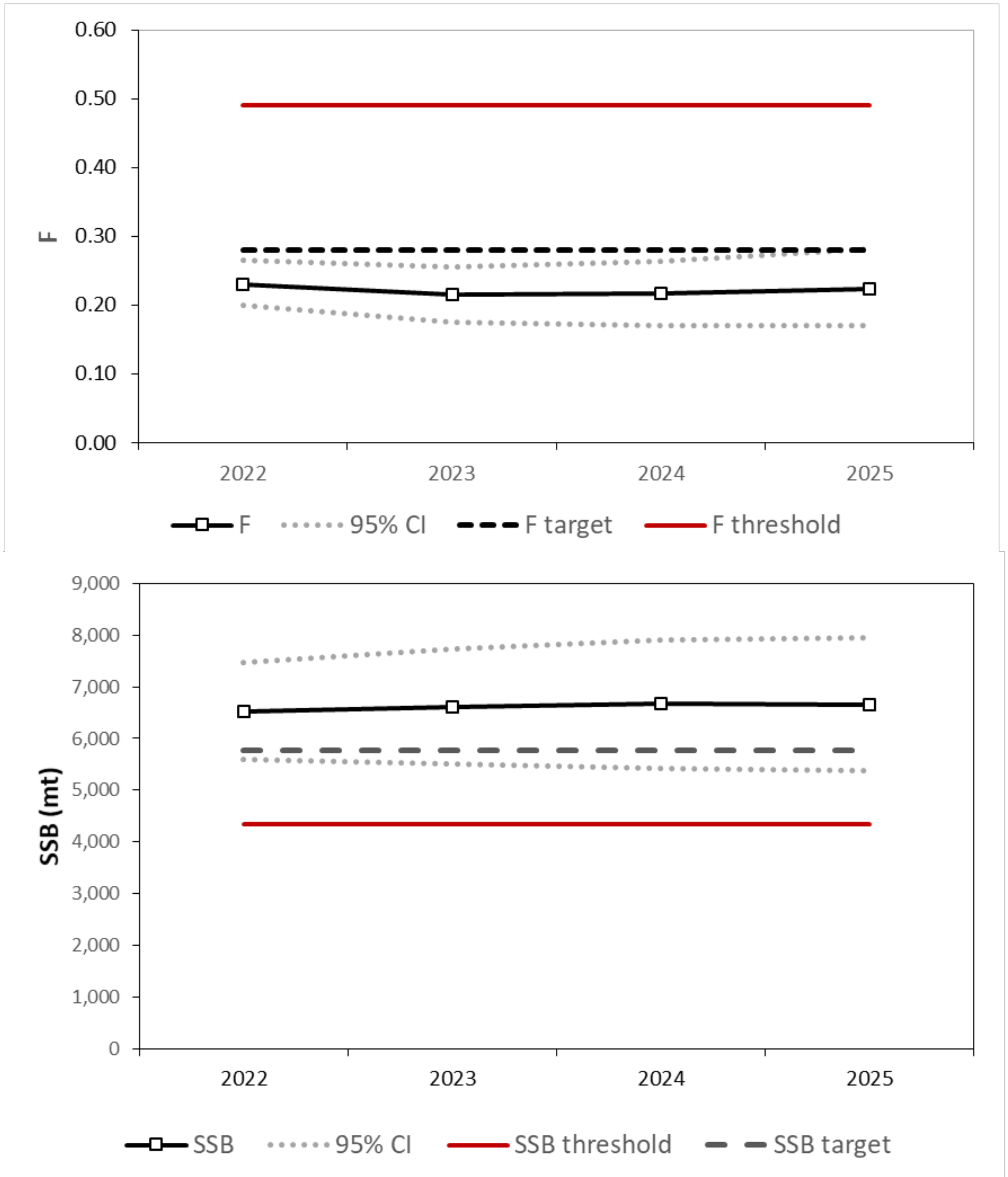


Figure 11. Status quo harvest projections for the MARI region showing the trajectory of annual *F* (top) and SSB (bottom) with their target and threshold reference points. Dotted grey lines indicate the 95% confidence intervals of the estimates.

Tautog Stock Assessment Update
LONG ISLAND SOUND REGION
2021

Executive Summary

The 2020 Long Island Sound (LIS) tautog stock assessment update used the Age Structured Assessment Program (ASAP) version 3.0.17, available through the Northeast Fishery Science Center (NEFSC) National Fishery Toolbox (NFT) which is a "data rich," forward projecting statistical catch at age program to assess tautog populations. The model incorporated annual harvest estimates, adult fishery-independent and fishery-dependent biomass, available age structure, size-at-age, and juvenile abundance indices. The ASAP model assumed a single fleet with four selectivity periods based on management time blocks. The assessment update used the calibrated MRIP data, a departure from the previous update. As the annual harvest estimates increased by an average of 143% between the uncalibrated and calibrated MRIP, a bridge model was evaluated. The bridge model covered the same time period (1984–2015) as the previous update but used the newly calibrated MRIP data. There was no status change in the terminal year between the previous update and the bridge model. As there were fewer MRIP samples in 2020 (due to the COVID-19 pandemic) a base model was conducted for the region using the MRIP CPUE index developed from non-imputed MRIP data. A sensitivity analysis was also conducted for the model using imputed MRIP data in the MRIP CPUE to evaluate model sensitivity to input data. Stock status in the terminal year was consistent between both base and sensitivity models. Additionally, stock status in 2015 for the base and sensitivity models were consistent with the previous update. The current update indicated that the stock is not overfished and not experiencing overfishing. This is a change from the stock status in 2015, when the stock was overfished and overfishing was occurring. Short-term projections (five years) were conducted to evaluate the risk to the stock for maintaining status quo management. While there is little risk that the stock will be overfished in the near future, the stock is still at risk for overfishing with the current level of removals, so precaution should be taken in management decisions.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The time series for commercial and recreational removals was extended from the previous assessment update (ASMFC 2017) through 2020, along with the associated age compositions from both sources.

This assessment update used the new, calibrated estimates of recreational removals from the Marine Recreational Information Program (MRIP). The calibrated estimates of recreational removals (harvest and dead discards) were consistently higher across the entire time series, averaging about 143% higher than the uncalibrated estimates (Figure 12).

The tautog fishery in the LIS region is predominantly recreational (Table 8, Figure 13). Recreational removals make up 95% of total removals by weight in the region. Total recreational removals were high but variable at the beginning of the time series, averaging about 1,306,630 fish from 1984–1991. Recreational removals declined significantly after that, averaging about 561,343 fish from 1992–2020. Recreational removals from 2018–2020, after the implementation of Amendment 1 to the Tautog FMP, averaged about 742,624 fish.

Commercial landings peaked in the mid-to late 1980s, averaging 125 mt per year from 1986–1990 before declining to a series low of 8.9 mt in 1999 (Table 8, Figure 13). Commercial landings increased since then, averaging 58 mt from 2018–2020, under Amendment 1.

The calibrated MRIP length frequencies were used to calculate the age composition of the recreational harvest and were also used as a proxy for the length composition of the commercial harvest. Data from the MRIP at-sea headboat observer program, the Connecticut Volunteer Angler Survey, and the American Littoral Society (ALS) volunteer tagging program were used to calculate the age composition of the recreational release mortality. Ages 5–7 made up the majority of the total removals over the time series (LIS Appendix 1).

The Tautog TC developed a fishery dependent index of abundance from MRIP recreational survey data, using the same “logical species guilds” from the benchmark assessment to identify tautog trips. Only non-imputed intercepts were used to calculate the index for 2020. The MRIP CPUE index was high and somewhat variable at the beginning of the series before declining through the mid-1990s to lower, stable, levels throughout the 2000s (Figure 14). In recent years, the index has been somewhat higher but more variable, with upticks in 2014, 2019, and 2020.

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The fishery independent indices from the LIS consist of the Connecticut Long Island Sound Trawl Survey, the New York Peconic Bay Trawl Survey, and the New York YOY Seine Survey (Table 9). Age composition information was available for the CT LIST survey and is shown in LIS Appendix 1. For all indices, statistical model-based standardization of the survey data was conducted to account for factors that affect tautog catchability.

The CT LIST survey is conducted in the spring and fall utilizing a stratified random design and was used to develop an index of age-1+ abundance for tautog. The survey was not conducted in 2020 due to COVID-19 restrictions; this survey is the source of CT’s age and length samples for tautog, so as a result, the age-length key for the LIS region did not include CT data for 2020. The index was highest at the beginning of the time series and declined through the mid-1990s; it rebounded somewhat during the late 1990s and early 2000s and then remained at low, stable levels; the index was higher than in the early 2000s in three of the last four years (Figure 14).

New York YOY Seine Survey operated from 1984 to the present, with a consistent standardized methodology starting in 1987. It is a fixed site survey that is conducted in three separate embayments on Long Island; the data were subset to bays on the north side of Long Island for the LIS region. It was used to develop a YOY index of recruitment for tautog. New York YOY Seine Survey was conducted in 2020 but the start was delayed due to COVID-19 restrictions. The index was variable with periods of higher recruitment including the early 1990s and the early 2000s; in recent years the index has been lower (Figure 14).

NYDEC Peconic Bay trawl survey operated from 1987 to the present, with a consistent standardized methodology starting in 1991. Sixteen stations are randomly sampled from May to October and target age-1 individuals. The survey was not conducted in 2005, 2006, and 2008. The index is highly variable with a few periods of higher recruitment including the late 1980s and the mid-2010s (Figure 14).

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (M, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised M value) from benchmark.

Life history parameters were the same as used in the peer-reviewed benchmark stock assessment (Table 10).

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

The 1984–2015 assessment, the bridge model, was updated with the new MRIP estimates to isolate the effects of the MRIP changes from the effects of adding additional years of data to the model. Spawning stock biomass was higher in the bridge model than the previous assessment (Figure 15). While SSB was similar for most years between the bridge model and the current update, there is a recent divergence as the current update estimated higher SSB in the 2010s. Overall, recruitment estimates were larger in the bridge model than the previous update and even larger in the current update (Figure 16). Fishing mortality was similar between the bridge model and the previous update, except in the terminal year (Figure 17). Overall, *F* was similar among the current update, the bridge model, and the previous update, although F was higher in the early 1990s and early 2000s. According to the bridge model, there was no status change from the previous update: LIS was overfished and in overfishing in 2015 (LIS Appendix 2 Table A2.1 and Table A2.2). The consistency between the previous update and the bridge model indicates that the mean increase of 143% in the calibrated MRIP data (Figure 12) did not impact stock status.

The current update was conducted using calibrated MRIP data. There were a few changes in how these data were prepared for the model input from the previous assessment. New York did not code “area C” in 2016 for the MRIP observations, so there was no LIS-specific catch estimates. Harvest and discards for 2016 LIS in NY were estimated by applying the mean proportion of LIS-specific harvest from 2013–2017 to the 2016 NY data. The New York headboat survey program ended in 2015 which was a loss of an important data source for both catch and release length observations. As such, there were only 6 NY length and age fishery dependent samples (harvest only) after 2015 and all of these were in 2019.

The other departures from the previous update were due to the COVID-19 pandemic. These included: no MIRP type-9 sampling in 2020, no LISTS in 2020, and fewer MRIP intercepts in 2020. As there were no MRIP type-9 data from 2020, all 2020 discard lengths were from the CT Volunteer Angler Survey and the data from the American Littoral Society tagging program. Due to the nature of these surveys, all fish lower than the minimum size of 16 inches were considered to be "released" fish. There was no abundance survey for fish older than 1 year in 2020 as the LISTS was not conducted. As there were fewer MRIP intercepts in 2020, two models were evaluated. The base model used the MRIP index developed only with non-imputed 2020 data and a sensitivity model used the MRIP index that included imputed 2020 data. There was no difference in stock status between the base model and the sensitivity model (LIS Appendix 2 Table A2.1 and Table A2.2).

Retrospective analysis was run from 2013–2020. While there was a strong retrospective pattern, the bias was generally conservative. Fishing mortality was overestimated in all but one year (Figure 18) and SSB was underestimated in all but two years (Figure 19). Recruitment was overestimated in 3 of 7 years (Figure 20). In the case of recruitment overestimation, two of the years were overestimated by less than 13%. In the other year recruitment was overestimated by 72%. For fishing mortality and SSB, the retrospective adjustment was within the 95% confidence intervals, so no adjustment was needed (LIS Appendix 2 Figure A2.1).

Spawning stock biomass was highest at the beginning of the time-series and declined steadily to a low in 1995, during a period when the stock was experiencing high *F* (Table 11, Figure 21). As *F* declined, the stock recovered somewhat in the early 2000s. The recovery was interrupted by increasing *F* and a decline in SSB in the late 2000, but decreasing *F* and strong recruitment events over the last 10 years resulted in an increasing trend in SSB in recent years (Table 11, Figure 21).

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

The updated SSB reference points for the LIS region were higher than the values from the 2016 assessment as a result of the scale change from the MRIP calibration, but the *F* reference points were more similar (Table 12).

The ASAP model runs indicated overfishing was not occurring in Long Island Sound in 2020 relative to MSY reference points. Both the point estimate of F_{2020} = 0.34 and the 3-year average value of F_{3yr} = 0.30 were below the *F* threshold value of 0.38 (Table 13, Figure 21).

The ASAP model runs indicated the tautog stock was not overfished in Long Island Sound relative to MSY reference points. SSB in 2020 was 6,665 mt, above the $SSB_{75\%MSY}$ threshold of 5,044 mt but below the SSB_{MSY} target of 6,725 mt (Table 13, Figure 21).

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

Short term projections in AgePro were used to predict the impact of status quo management on the population. Overall, the stock is not at risk for becoming overfished in the near future, but is at risk for overfishing to occur. The short term projection using the F_{Target} estimate resulted in only a 3% probability of being at or below F_{Target} in the terminal year (Table 14, Figure 22). A projection using $F_{Threshold}$ resulted in a 27% probability of being above $F_{Threshold}$. These projections showed a 97% probability of being at or above $SSB_{Threshold}$ in 2025 but only a 66% probability of being at SSB_{Target}. These results were quite similar to the sensitivity analysis using the imputed MRIP CPUE.

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

The research recommendations from the previous update should be an area of prioritization. Increased fishery dependent biological sampling (length and age for both harvest and released fish) would greatly benefit the stock assessment process and improve management.

For the next benchmark assessment, utilizing a modeled age-length key (Gerritsen et al. 2006) could help to avoid borrowing age-length data from other years and regions, this approach was recently implemented to evaluate the impact of harvest slot limits on tautog in the LIS region (Kasper et al. 2020). Additionally, modeling the harvest and discard at length distributions, rather than using the actual harvest and discard length observations, would help to manage the small sample size for such observations.

List of Appendices

Appendix 1: ASAPplots output of the base model
Appendix 2: Retrospective adjustment and sensitivity runs

References

ASMFC. 2017. Atlantic States Marine Fisheries Commission 2016 Tautog Stock Assessment Update. Atlantic States Marine Fisheries Commission.

Gerritsen, H. D., D. McGrath, and C. Lordan. 2006. A simple method for comparing age–length keys reveals significant regional differences within a single stock of haddock (*Melanogrammus aeglefinus)*. ICES Journal of Marine Science 63:1096–1100.

Kasper, J. M., J. Brust, A. Caskenette, J. McNamee, J. C. Vokoun, and E. T. Schultz. 2020. Using Harvest Slot Limits to Promote Stock Recovery and Broaden Age Structure in Marine Recreational Fisheries: A Case Study. North American Journal of Fisheries Management 40:1451–1471.

Tables

Table 8. Total removals in metric tons by sector for the LIS region.

Year	Recreational Harvest	Recreational Release Mortalities	Commercial Harvest
1984	1,413.1	3.0	
1985	2,389.6	6.3	
1986	2,179.7	3.2	129.4
1987	2,483.9	5.9	159.1
1988	1,779.0	6.0	116.9
1989	1,794.0	5.7	140.4
1990	1,518.5	7.8	77.9
1991	1,373.1	8.8	76.2
1992	1,195.2	6.3	74.4
1993	1,254.6	5.1	60.0
1994	837.0	5.9	33.5
1995	472.1	4.4	11.1
1996	252.1	3.3	51.5
1997	262.3	3.5	31.9
1998	381.5	9.7	26.0
1999	508.0	8.0	8.9
2000	154.3	2.5	9.1
2001	151.5	4.8	15.6
2002	1,625.2	19.9	20.4
2003	735.5	9.5	31.9
2004	717.9	10.1	40.8
2005	370.7	5.5	33.6
2006	885.2	13.8	39.3
2007	1,695.5	25.9	54.6
2008	1,371.7	15.5	37.5
2009	1,371.2	14.8	21.5
2010	1,003.7	13.7	25.2
2011	340.7	12.2	33.1
2012	1,224.8	67.6	25.4
2013	972.4	55.2	31.8
2014	1,053.6	93.8	39.6
2015	1,356.3	88.3	29.7
2016	1,519.1	85.3	33.3
2017	833.0	81.5	47.9
2018	303.2	61.1	38.8
2019	1,550.5	99.2	76.3
2020	1,120.4	96.2	58.0

Table 9. Indices used in the ASAP model for the LIS region.

Index Name	Index Metric	Design	Time of Year	Years	Ages
MRIP CPUE	Total catch per angler-trip	Stratified Random	Mar-Dec	1984-2020	2+
Connecticut LIS Trawl Survey	Mean number per tow	Stratified Random	April-June	1984-2019	2+
New York Peconic Bay Trawl Survey	Mean number per tow	Stratified Random	May-October	1985, 1987-1994, 1996-2009, 2011-2020	1
New York YOY Seine Survey	Mean number per haul	Fixed	July-Nov	1987-2004, 2007, 2009-2020	YOY

Table 10. Model structure and life history information used in the stock assessment for the LIS region.

	Value(s)
Years in Model	1984-2020
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%
Fraction of year before SSB clculation	0.42
Number of selectivity blocks	4
Selectivity periods	1984-1986, 1987-1994, 1995-2011, and 2012-2020
Selectivity type	Single logistic

	Age Group											
	1	2	3	4	5	6	7	8	9	10	11	12+
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 11. Spawning stock biomass, recruitment, annual *F*, and 3-year average *F* estimates for the LIS region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual *F*	3-year Average *F*
1984	13,786	2.83	0.17	
1985	13,092	2.16	0.23	
1986	12,198	3.14	0.23	0.21
1987	11,006	2.54	0.28	0.25
1988	10,004	2.71	0.26	0.26
1989	9,116	1.60	0.34	0.29
1990	8,301	1.56	0.27	0.29
1991	7,608	1.55	0.31	0.31
1992	6,386	1.25	0.48	0.35
1993	4,859	1.12	0.51	0.43
1994	3,614	1.23	0.72	0.57
1995	2,973	1.45	0.44	0.55
1996	2,978	1.24	0.31	0.49
1997	3,219	1.43	0.24	0.33
1998	3,547	1.79	0.21	0.25
1999	3,830	1.84	0.22	0.22
2000	4,319	1.46	0.14	0.19
2001	4,992	1.32	0.11	0.15
2002	5,193	1.41	0.41	0.22
2003	5,016	1.63	0.25	0.26
2004	5,086	1.22	0.19	0.28
2005	5,322	1.28	0.12	0.19
2006	5,520	1.09	0.18	0.17
2007	5,167	1.28	0.42	0.24
2008	4,372	1.89	0.46	0.35
2009	3,635	1.66	0.59	0.49
2010	3,303	1.60	0.52	0.52
2011	3,548	1.69	0.24	0.45
2012	3,912	1.82	0.45	0.40
2013	4,107	2.52	0.43	0.37
2014	4,325	2.68	0.45	0.44
2015	4,670	2.65	0.42	0.43
2016	5,087	2.05	0.49	0.45
2017	5,538	1.12	0.44	0.45
2018	6,128	3.38	0.21	0.38
2019	6,431	2.80	0.36	0.34
2020	6,665	1.58	0.34	0.30

Table 12. SSB and *F* reference points from 2016 and 2021 updates for the LIS region.

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
2016 Update	2,865	2,148	0.28	0.49
2021 Update	6,725	5,044	0.26	0.38

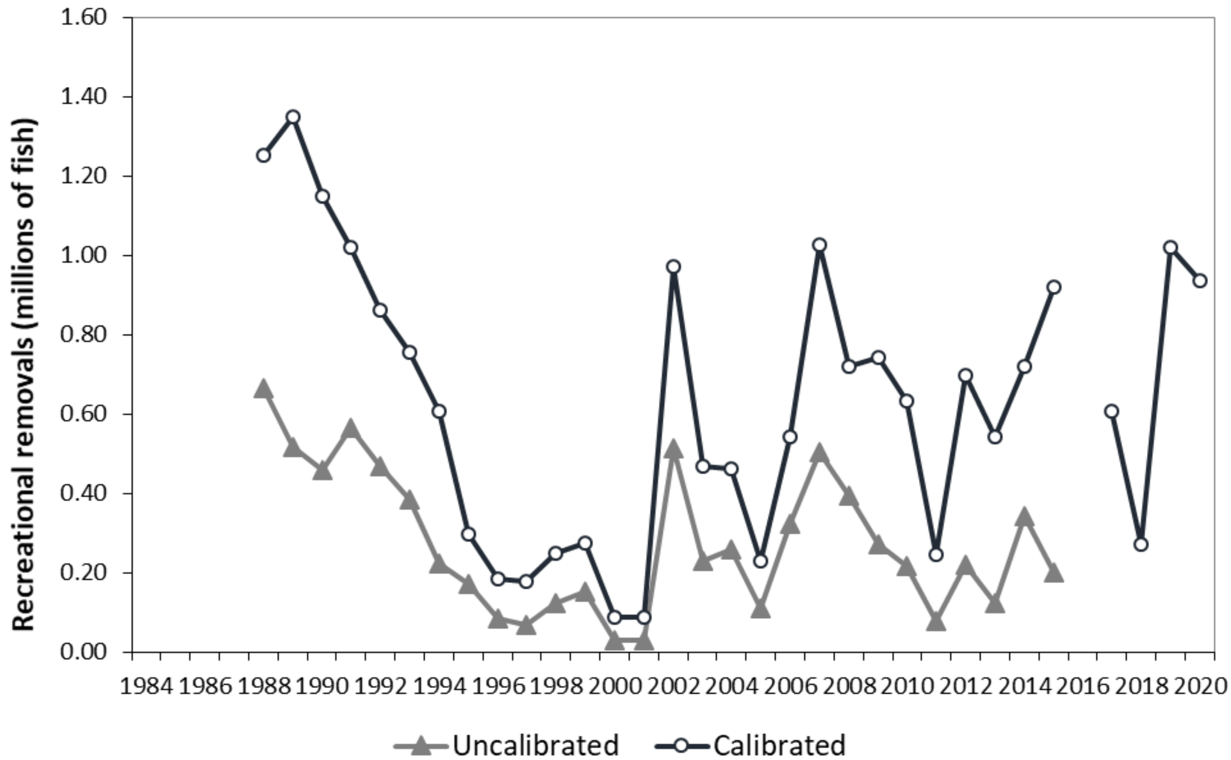
Table 13. Stock status for the LIS region.

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
Reference Points	6,725	5,044	0.26	0.38
2020 Estimate	6,665		0.3	
2020 Status	Not Overfished		Overfishing not Occurring	

Table 14. Short-term projection results for the LIS region using status quo removals.

Landings (mt) for 2021-2025	Probability of being at or below *F* Target in 3 years	Probability of being at or above SSB threshold in 3 years
Status quo (2018-2020 average)	3%	97%

Figures



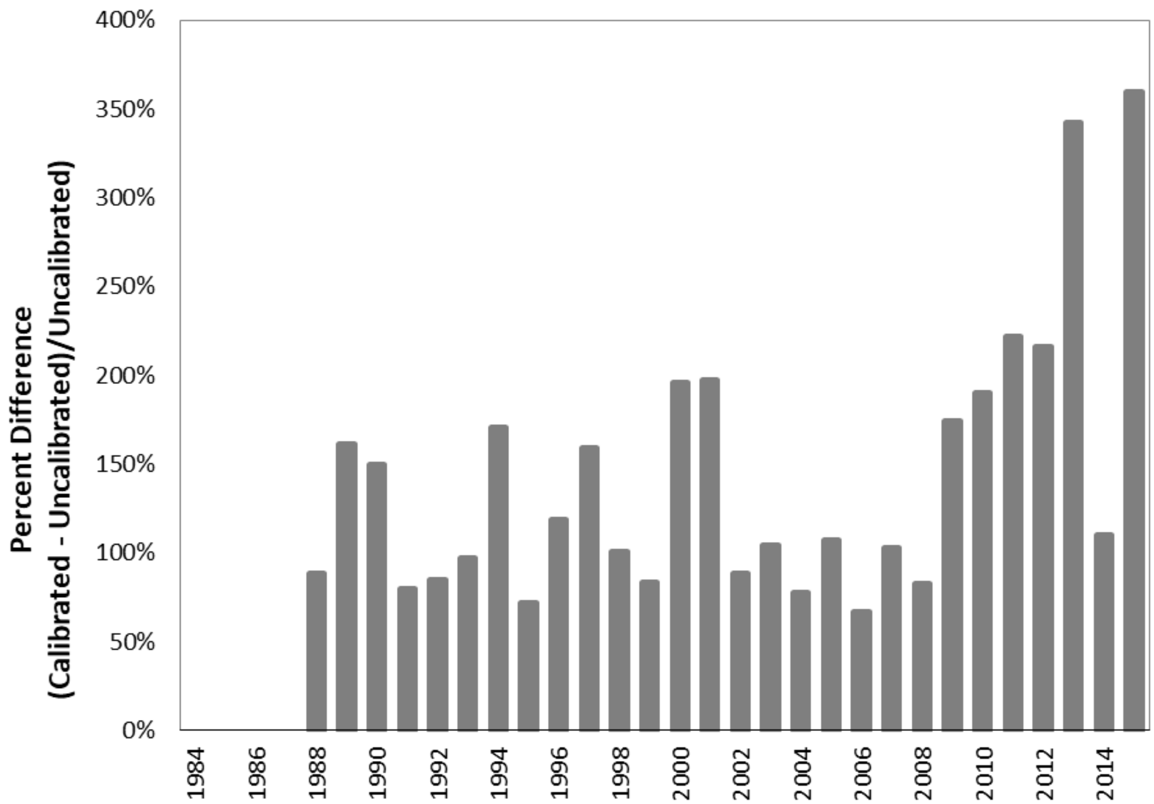


Figure 12. Comparison of calibrated and uncalibrated recreational removals (harvest + dead releases) in numbers of fish (top) and percent difference (bottom) for the LIS region.

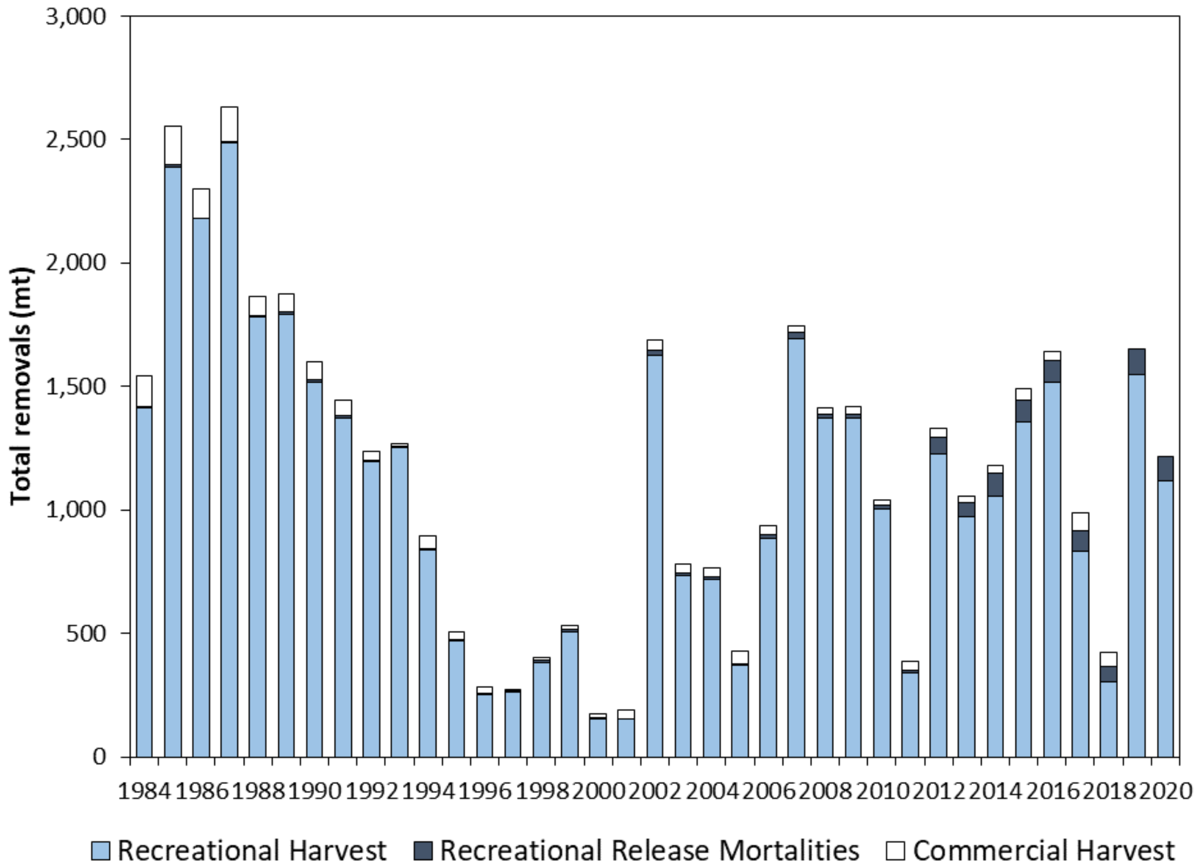


Figure 13. Total removals by sector for the LIS region.

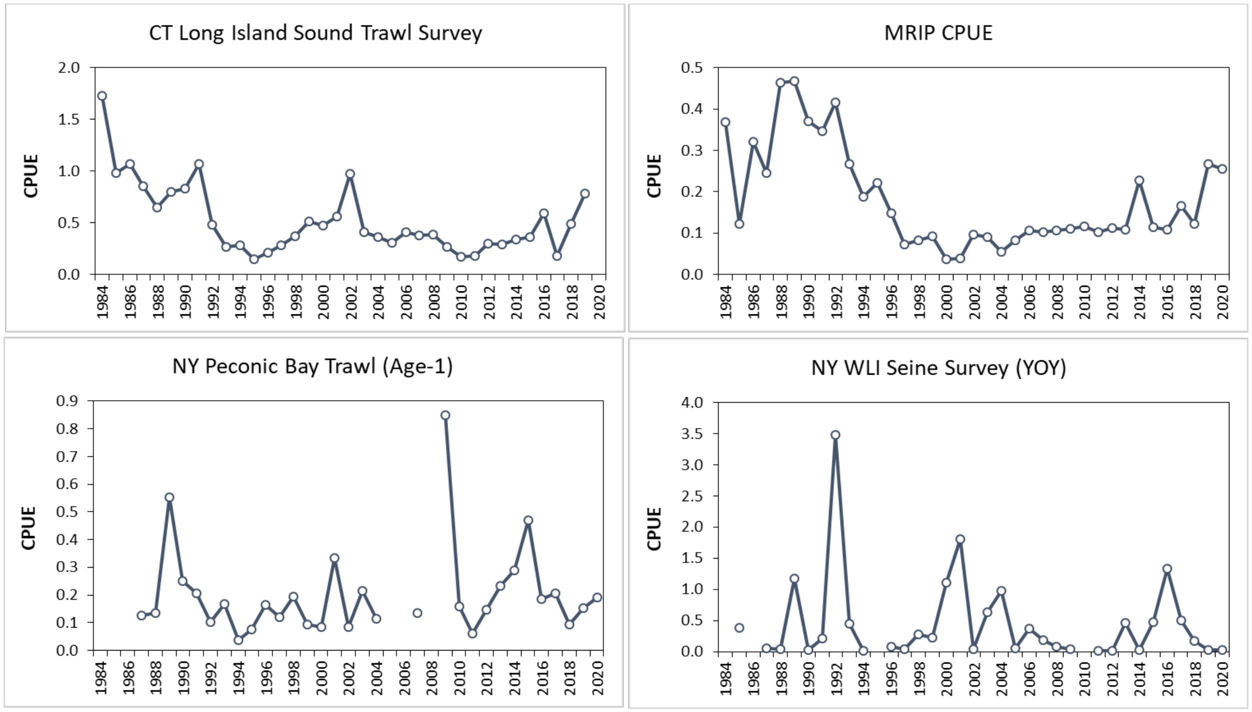


Figure 14. Indices of abundance used in the ASAP model for the LIS region.

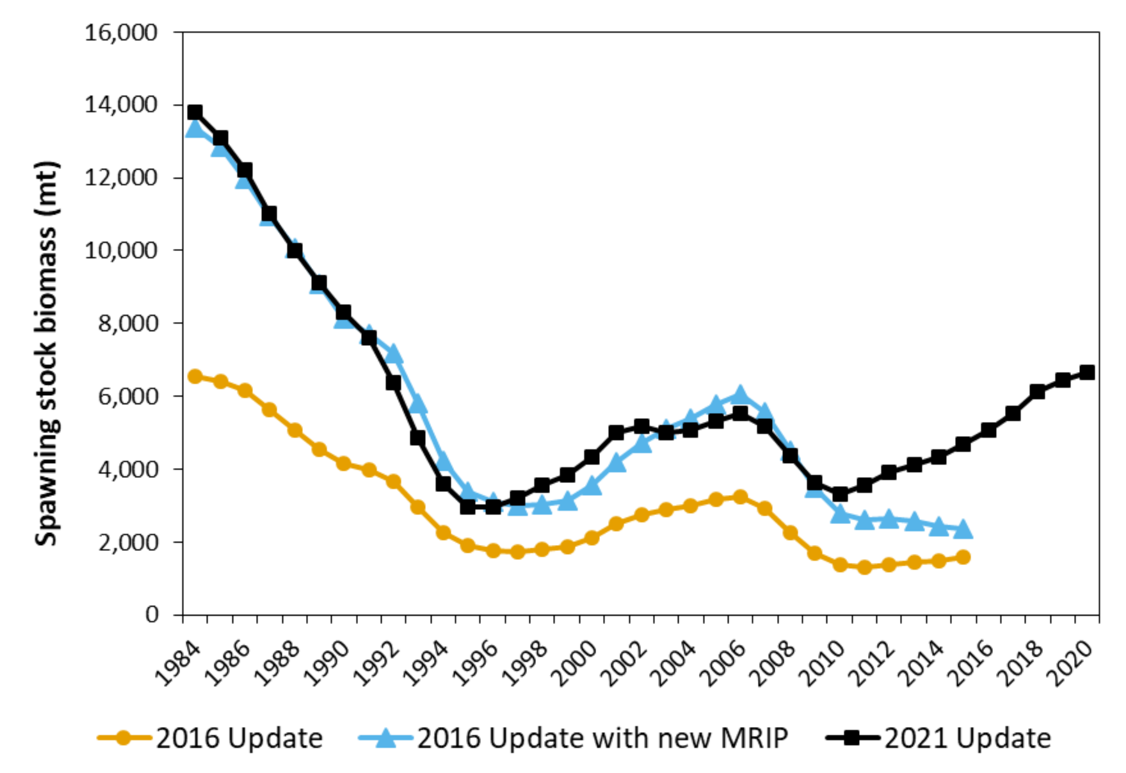


Figure 15. Estimates of spawning stock biomass for LIS region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

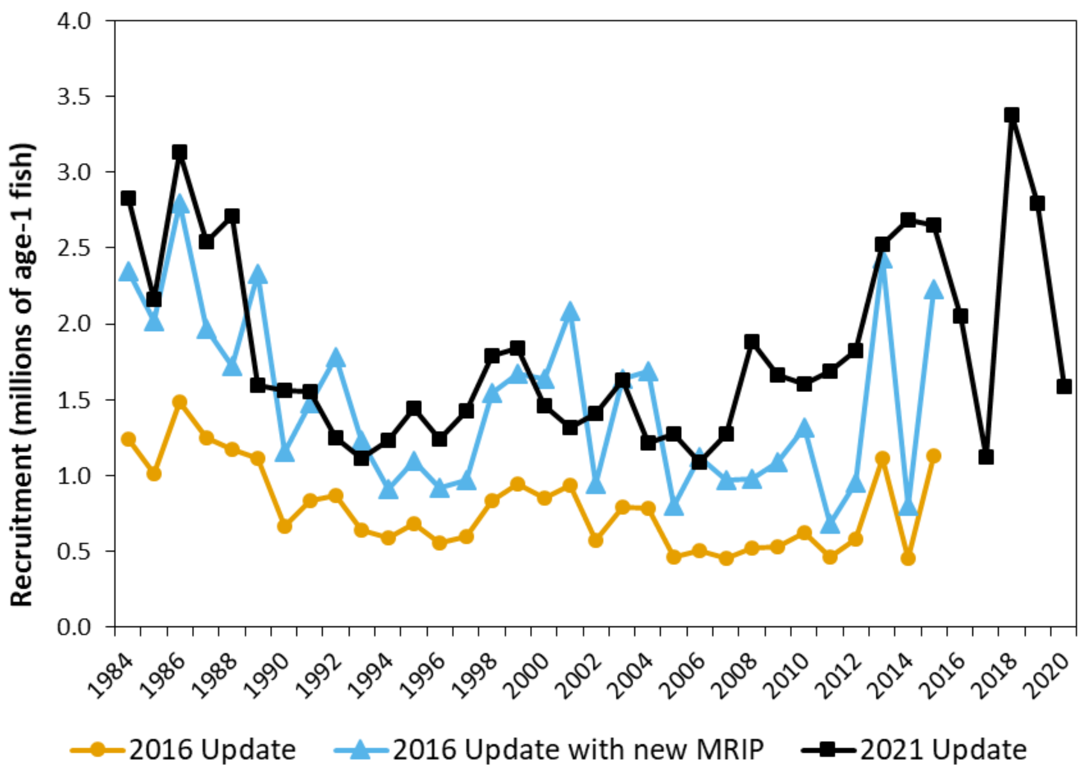


Figure 16. Estimates of recruitment for the LIS region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

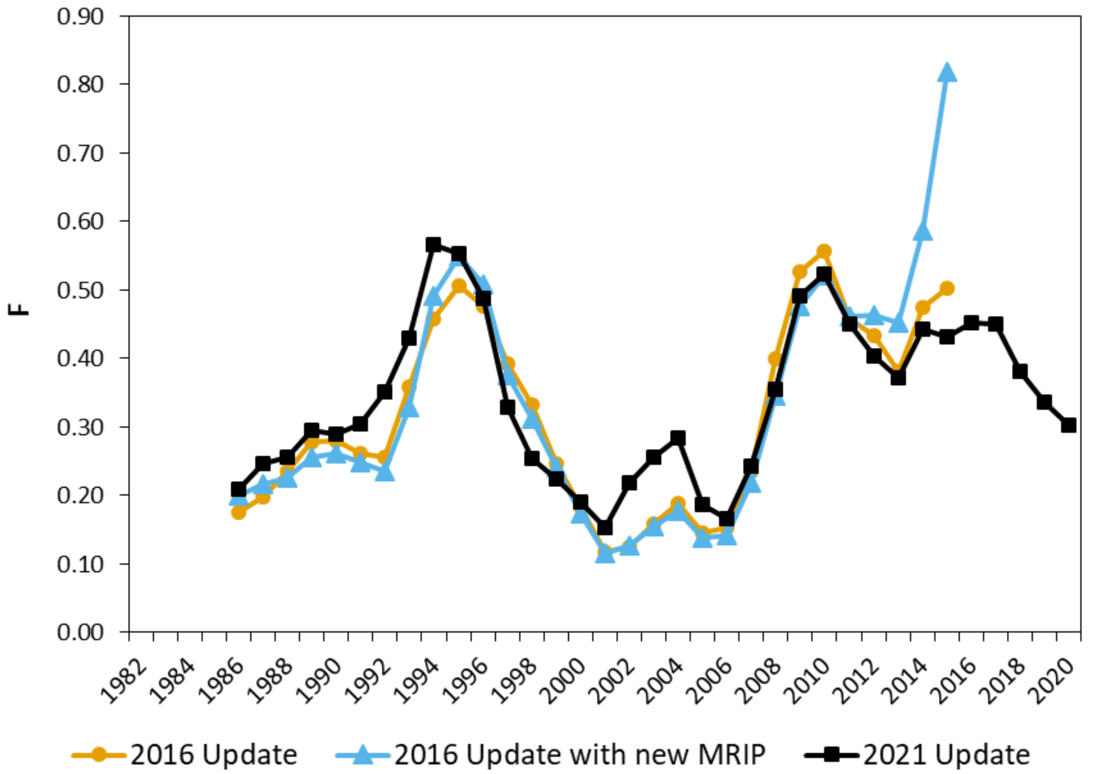


Figure 17. Estimates of the annual full *F* for the LIS region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

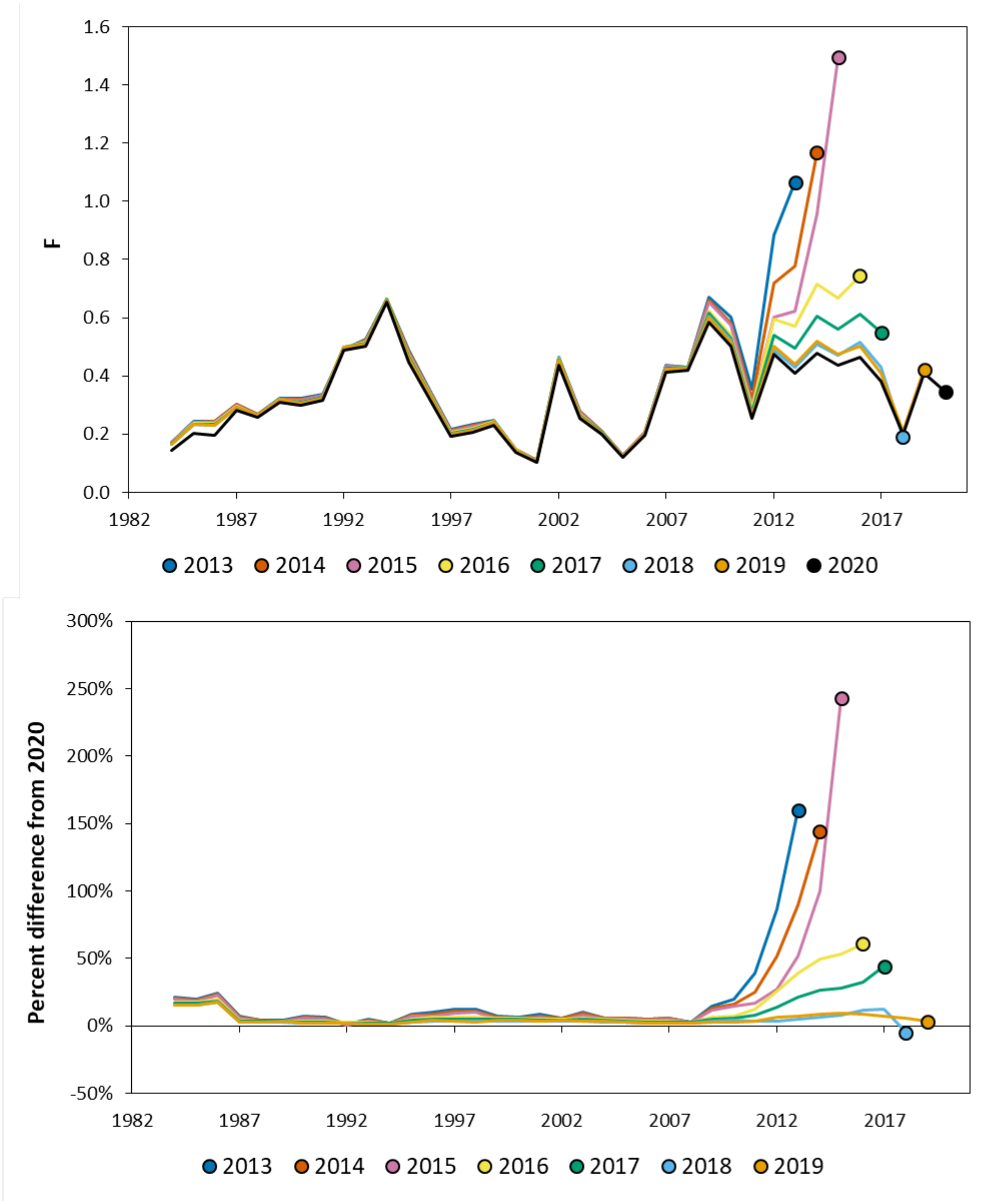


Figure 18. Retrospective analysis for annual *F* from the LIS region in absolute numbers (top) and percent difference (bottom).

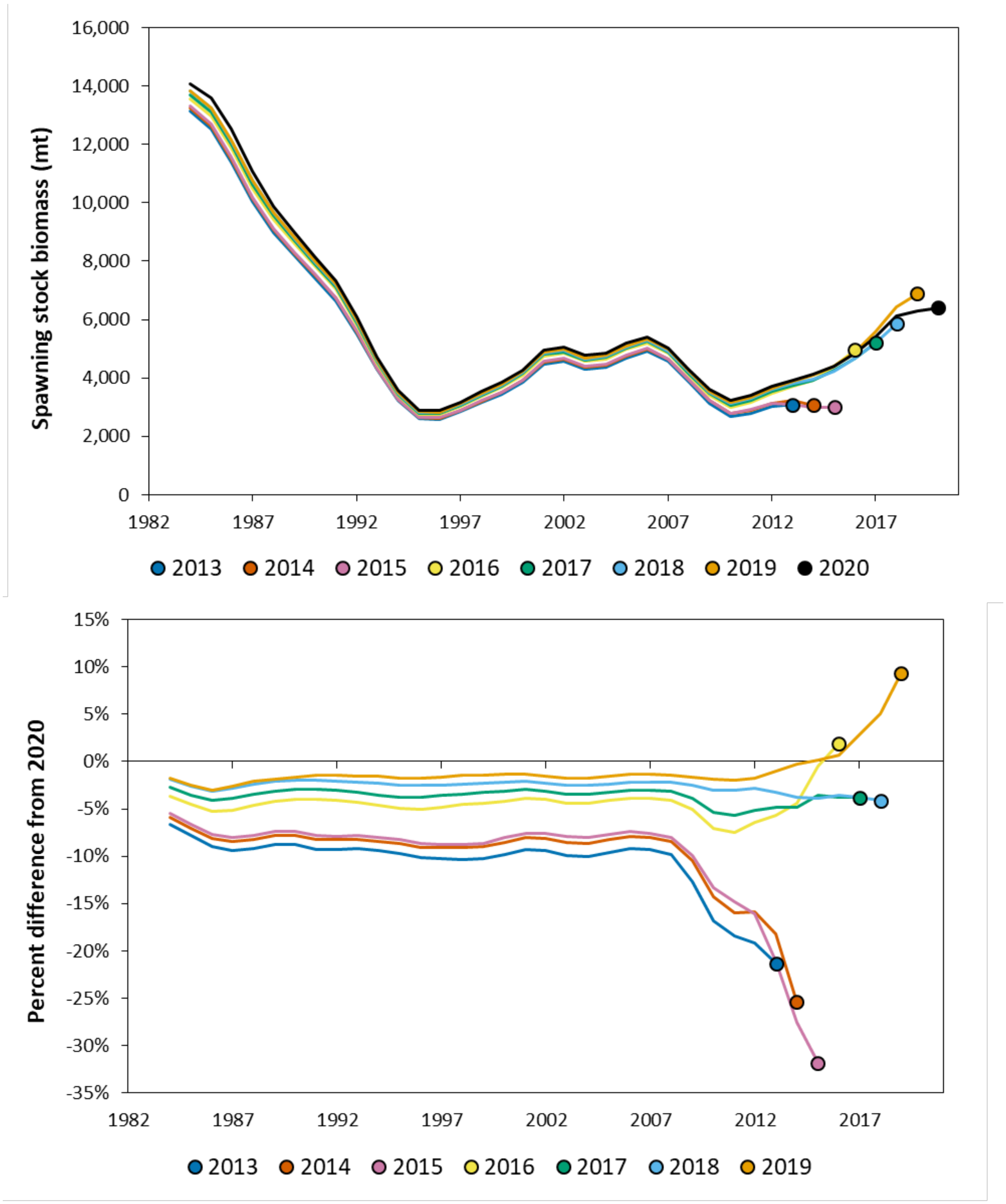
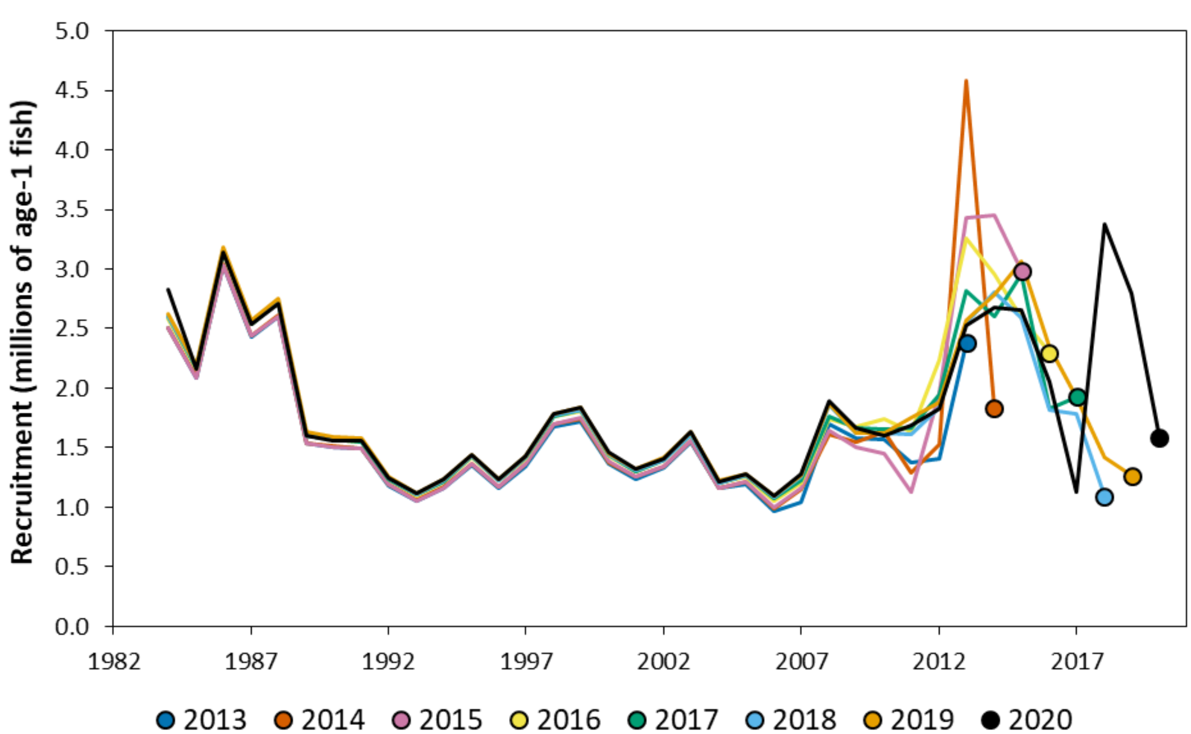


Figure 19. Retrospective analysis for annual SSB from the LIS region in absolute numbers (top) and percent difference (bottom).



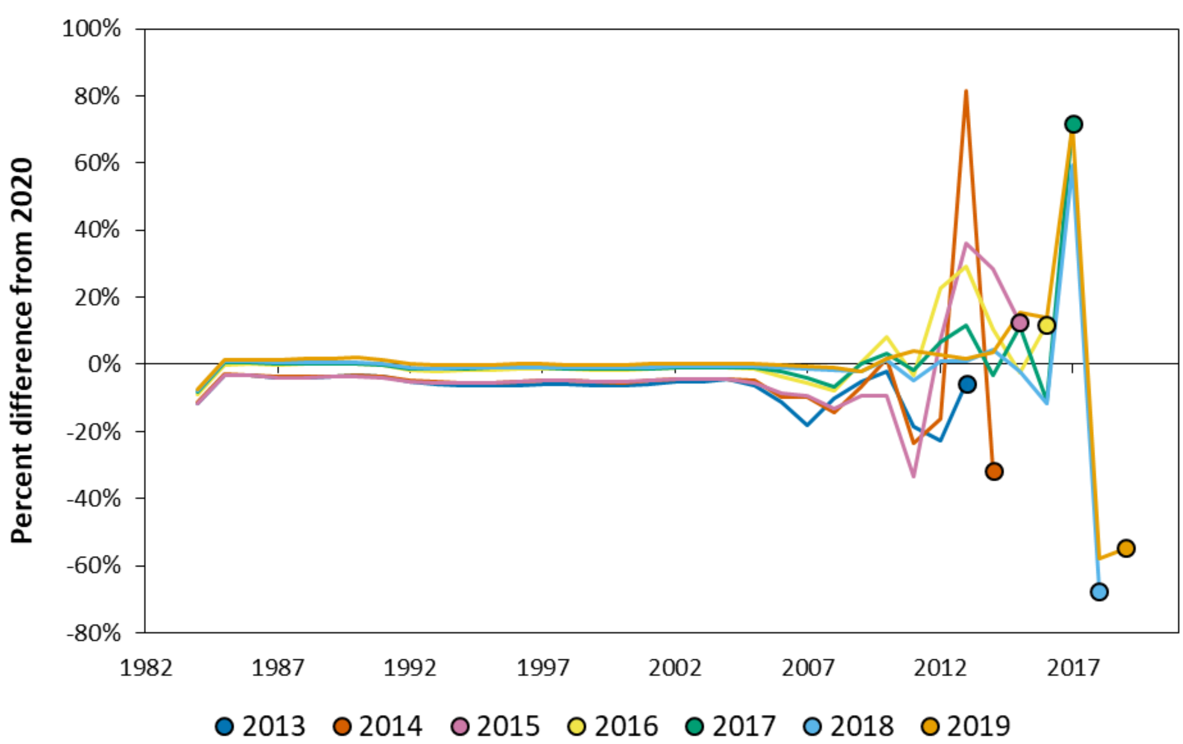


Figure 20. Retrospective analysis for annual recruitment from the LIS region in absolute numbers (top) and percent difference (bottom).

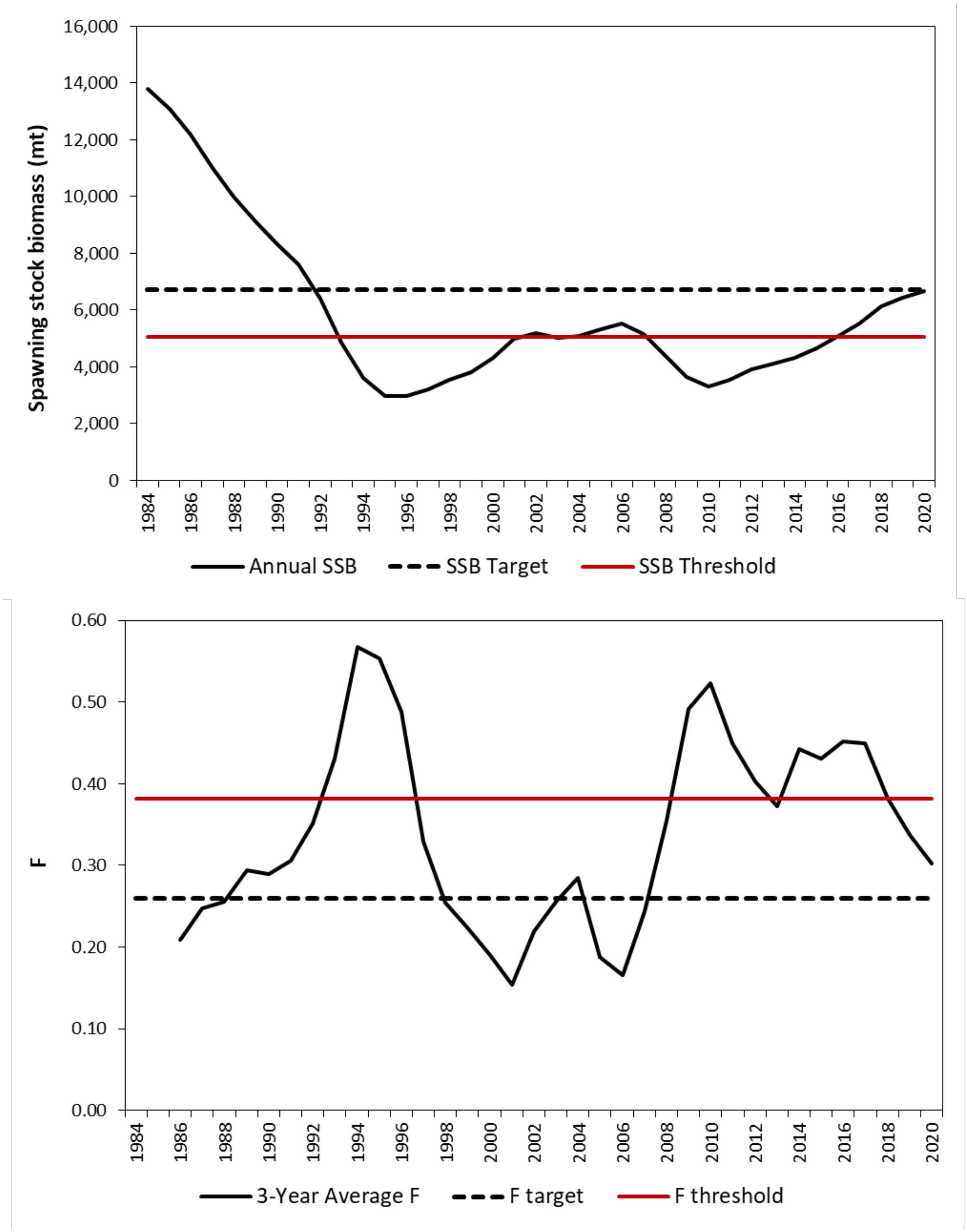
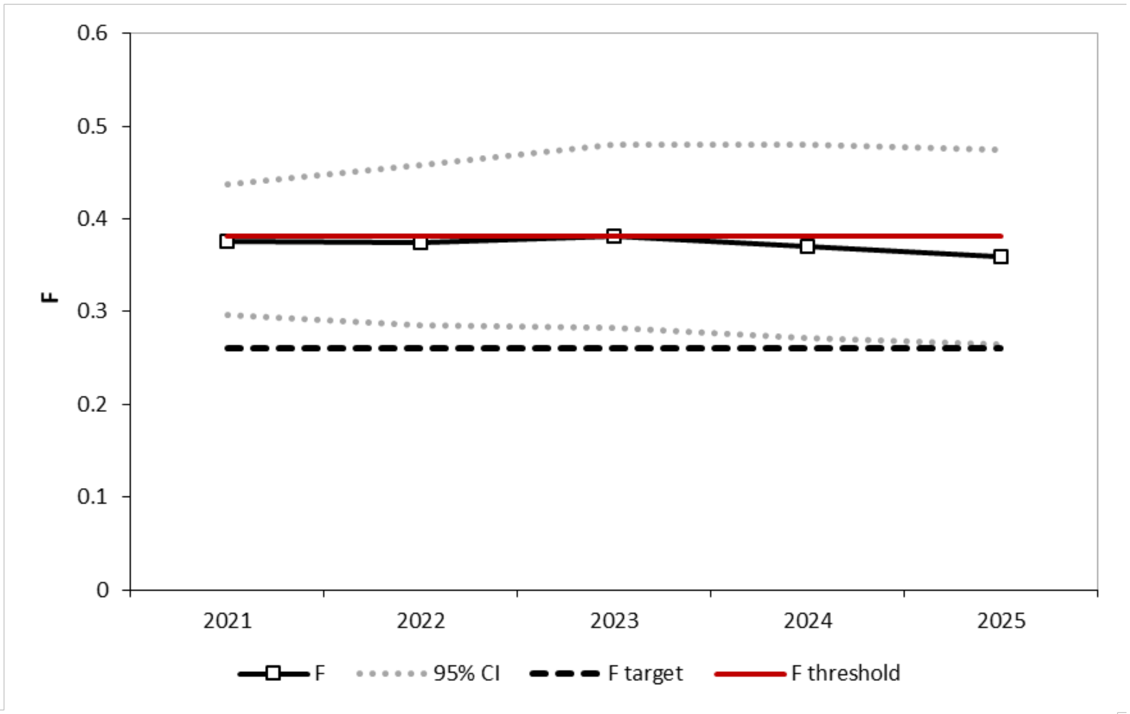


Figure 21. Annual SSB plotted with SSB target and threshold (top) and 3-year average *F* plotted with *F* target and threshold (bottom) for the LIS region.



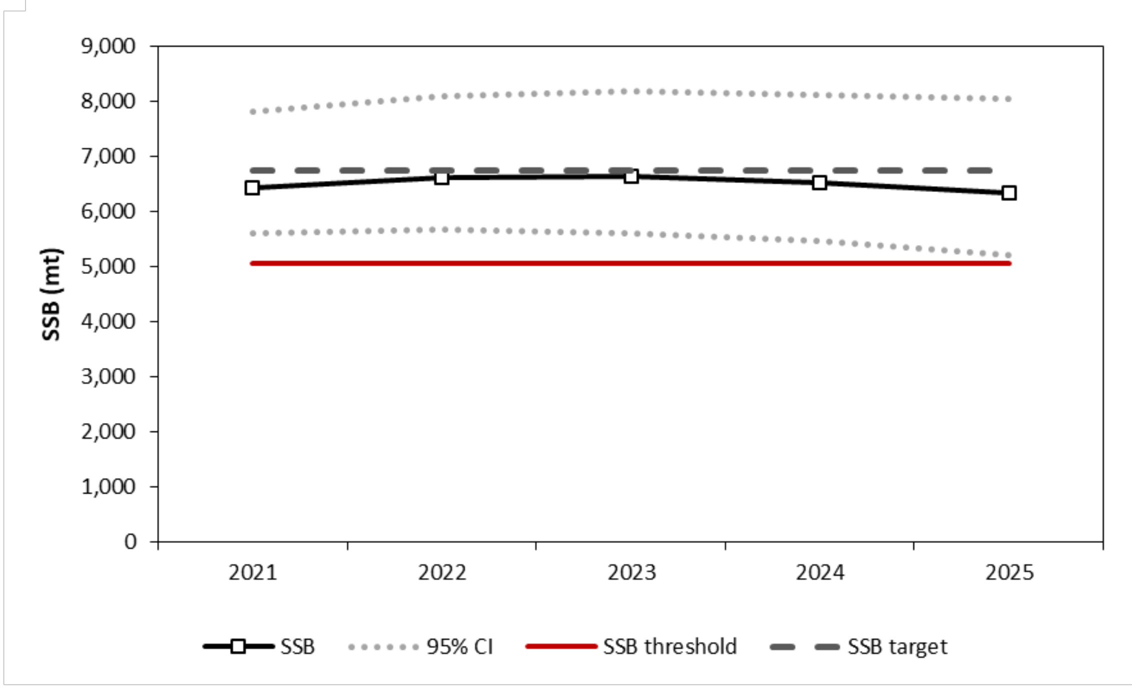


Figure 22. Status quo harvest projections for the LIS region showing the trajectory of annual *F* (top) and SSB (bottom) with their target and threshold reference points. Dotted grey lines indicate the 95% confidence intervals of the estimates.

Tautog Stock Assessment Update

NEW JERSEY-NEW YORK BIGHT REGION

2021

Executive Summary

This stock assessment is an update to the existing benchmark assessment for tautog (ASMFC 2015, ASMFC 2016); the previous assessment update was completed in 2017 (ASMFC 2017). This assessment updates the accepted statistical catch-at-age model with commercial and recreational fishery catch data and indices of relative abundance from fishery-independent and fishery-dependent data sources through the terminal year of 2020.

In the New Jersey-New York Bight (NJ-NYB) region, the stock was overfished, but overfishing was not occurring. The stock has shown an increasing trend since the last assessment update, with Spawning stock biomass (SSB) now just below the threshold in 2020.

This update includes the new time-series of calibrated recreational data from the Marine Recreational Information Program (MRIP). For the NJ-NYB region, the calibrated estimates averaged 133% higher than the uncalibrated estimates over the entire time series. The new MRIP estimates resulted in higher estimates of SSB and recruitment, but had less of an impact on *F*. Stock status has changed in this region since the last assessment update: NJ-NYB is still overfished but not experiencing overfishing. This appears to be related to reductions in *F* and increases in SSB in the most recent few years, as opposed to an artifact of the new MRIP numbers.

Short term projections using the average landings from the last three years resulted in a 15% probability of being at or below target F in 2025 and a 53% probability of being at or above SSB threshold in 2025.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

The time series for commercial and recreational removals was extended from the previous assessment update (ASMFC 2017) through 2020, along with the associated age compositions from both sources.

This assessment update used the new, calibrated estimates of recreational removals from MRIP. The calibrated estimates of recreational removals (harvest and dead releases) were consistently higher across the entire time series, averaging about 133% higher than the uncalibrated estimates (Figure 23).

The tautog fishery in the NJ-NYB region is predominantly recreational (Table 15, Figure 24). Recreational removals make up 96% of total removals by weight in the region. Total recreational removals were high but variable at the beginning of the time series, averaging about 2.8 million fish from 1983-1992. Recreational removals declined significantly after that, averaging about 800,000 fish from 1993-2017. Recreational removals from 2018–2020, after the implementation of Amendment 1 to the Tautog FMP, have averaged about 565,000 fish.

Commercial landings averaged 89 mt per year through the mid-1990s before quickly declining through the late 1990s, averaging 46 mt from 2000 to 2017 (Table 15, Figure 24). Commercial landings averaged 53 mt from 2018–2020, under Amendment 1.

The calibrated MRIP length frequencies were used to calculate the age composition of the recreational harvest and used as a proxy for the length composition of the commercial harvest. Data from the MRIP at-sea headboat observer program, the New Jersey Volunteer Angler Survey, and the American Littoral Society (ALS) volunteer tagging program were used to develop the age composition of the recreational release mortality. Ages 4-7 made up the majority of the total removals over the time series (NJ-NYB Appendix 1).

The Tautog TC developed a fishery dependent index of abundance from MRIP recreational survey data, using the same "logical species guilds" from the benchmark assessment to identify tautog trips (Table 16). Only non-imputed intercepts were used to calculate the index for 2020. The MRIP CPUE increased at the beginning of the series, peaking in the early 1990s before declining to lower but somewhat variable levels from the late 1990s to the present (Figure 25).

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

Fishery-independent indices from the NJ-NYB region consisted of the NJ Ocean Trawl Survey and the New York Western Long Island Seine Survey (Table 16, Figure 25). Age composition information was available for the NJ Ocean Trawl survey and is shown in NJ-NYB Appendix 1. For all indices, statistical model-based standardization of the survey data was conducted to account for factors that affect tautog catchability.

The NJ ocean trawl survey, which began in 1989, is conducted 5 times annually from January through October utilizing a stratified random design and is used in the assessment as an index of age-1+ tautog abundance. The survey was not conducted in 2020 due to COVID-19 restrictions. The index was variable but indicated a period of high abundance at the beginning of the time series, declined through the late 1990s, then recovered to moderate abundance between 2000 and 2010. The index has been variable since 2010 showing early declines in 2011-2012, a moderate recovery from 2013 to 2016, then declining again in 2017 and remaining low through 2019 (Figure 25).

The NY WLI seine survey has operated from 1984 to the present, with a consistent standardized methodology starting in 1987. It is a fixed site survey that is conducted in three separate embayments on Long Island; the data were subset to Jamaica Bay on the south side of Long Island for the NJ-NYB region. The WLI seine index captures mainly age- 0 fish, so was lagged forward one year and treated as an age-1 index. It was used to develop a YOY index of recruitment for tautog. The NY WLI seine survey was conducted in 2020 but the start was delayed due to COVID-19 restrictions. The index was variable with periodic years of higher recruitment including the early 1990s and the early 2000s; recent years from 2012 to 2018 showed time-series highs before declining sharply in 2019 and 2020 (Figure 25).

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (M, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised M value) from benchmark.

Life history information used in this update continued using the same values as those utilized in the benchmark assessment (Table 17). Natural mortality was set at 0.15. The age plus group included ages 12 and over. The start year was set at 1989 with the terminal year of 2020 which adds 5 additional years of data since the last assessment. The maturity schedule remained the same as the benchmark with 0 for ages 1 and 2, 0.8 for age 3, and 1 for ages 4 through 12 plus. One additional selectivity block was incorporated in this update to reflect the changes in seasons and bag limits for the years 2018 through 2020, resulting in a total of 5 selectivity blocks utilized for this assessment (Table 17).

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

Comparison runs were made for *F*, SSB and recruitment using the original 2016 assessment estimates and a continuity bridge run through 2015 using the calibrated MRIP values to isolate the effect of the MRIP calibration from the effect of adding more years of data. Comparison runs for SSB showed a marked increase in scale for the models using the calibrated MRIP values (continuity and the 2021 update) over the 2016 assessment run, yet all 3 show a similar pattern with an upward trend in the latest years (Figure 26). Comparison model runs for recruitment show a similar difference in scale as seen for SSB (Figure 27). However, both the 2016 update and the continuity runs show a spike upward for 2013 to 2014 which is absent in the 2021 update. The upward spike may be an artifact of the way the ASAP model estimates recruits since the 2021 update shows a sharp upward spike in 2018 which is within the 2-year window from the terminal year as seen for the models with 2015 as the terminal year. Both the 2016 update and continuity run estimates for *F* were higher than the 2016 update early in the time series from 1995 to 1996 and again in 2014 (Figure 28). The 2016 assessment *F* values diverged upward from the other 2 runs in 2007 and 2008 and spiked sharply upward during the years 2010 through 2012, Otherwise all 3 runs seemed to track closely with each other, and all their 2015 *F* estimates were in fairly close agreement.

Retrospective analyses peeling back 7 years from 2020 through 2013 for F and SSB showed discernible patterns. Previous year estimates overestimated *F* by a range of 9% to just over 100% (Figure 29), while SSB was shown to have been underestimated in the previous 3 years by a range 5% to 15% (Figure 30). The Mohn's rho adjusted estimates for *F* (0.22) and SSB (3,614 mt) fell within the 95% CI of 0.08-0.39 for the current *F* estimate of 0.24 and within the 95% CI of 2,989 mt-6,575 mt for the current SSB estimate of 4,782 mt (NJ-NYB Appendix 2 Figure A2.1), so a retrospective adjustment was not conducted. The retrospective analysis for recruitment showed much greater variability than those for *F* and SSB but seemed to show a general pattern of overestimating recruits in most years by a range of 3% to 88% (Figure 31). Recruits in 2020 were estimated to number about 1.4 million fish (standard deviation of about 765,000).

Sensitivity runs included individually dropping each survey index and utilizing the MRIP index calculated with imputed values for 2020. The sensitivity runs generally show most model estimates of SSB and *F* tracking closely with the 2021 update through most of the time series through 2015. The model without the NJ Ocean Trawl Survey showed consistently lower SSB estimates through 2007 and then yielded higher values from 2010 through 2018 before nearly matching the 2021 update estimate in 2019. The other 3 models diverged from the 2021 update after 2015 with the model minus the MRIP index showing sharply higher SSB estimates from 2018 through 2020. The model without the NY WLI Seine Survey and the model using the imputed MRIP index showed lower estimates than the 2021 update after 2015, however the model with the imputed MRIP index follows the upward trend seen in the other model runs. The model without the NY WLI Seine index shows a slight dip in the terminal year. The sensitivity runs showed only slight differences from the 2021 update run for F estimates, with the model minus the NJ Ocean Trawl Survey index showing the most divergence with slightly higher F estimates early in the time series during the 1990s, and then slightly underestimating F since 2009 (NJ-NYB Appendix 2 Figures A2.2).

For recruitment, the sensitivity runs show all model runs tracking closely through the time series through 2012 then the model without the NY WLI Seine index and the model without the MRIP index diverge in opposite directions (NJ-NYB Appendix 2 Figure A2.4). The model without the NY WLI Seine drops below the 2021 update while the model without the MRIP index tracks a higher recruitment through 2018. However, all the models estimated terminal year values that are within 0.4 million of each other. The models without the MRIP, NJ Ocean Trawl and with the imputed MRIP indices all show a dip from 2019 to 2020 while the model without the NY WLI Seine index shows an increase in the final year which is reflected in the slight increase seen in the 2021 update run.

Overall, the sensitivity runs seem to indicate that none of the indices has a significant impact on the *F* estimates, but both the NY WLI and MRIP indices seem to influence the SSB and recruitment estimates in opposite directions: the NY WLIS index impacting the SSB and recruitment in an upward direction while the MRIP index appears to have a dampening effect on those values (NJ-NYB Appendix 2 Figures A2.2-A2.4).

Overall, spawning stock biomass in the NJ-NYB region has declined since the beginning of the time series; there were brief periods of increasing SSB as F declined, but as F increased again, those increases would reverse (Table 18, Figure 32). SSB reached a low in 2011 but has been increasing since then. The 3-year average of F has been highly variable over time, with alternating periods of being above and below the F threshold; F has been declining since 2016 (Table 18, Figure 32)

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

Biological reference points were scaled up for spawning stock biomass and decreased for fishing mortality due in part to the increased values from the calibration of MRIP landings. The SSB target and threshold values increased from those in the 2016 update to a target SSB of 6,552 mt and threshold SSB of 4,890 mt (Table 19). Target and threshold *F* decreased from those in 2016 to target F of 0.19 and threshold *F* of 0.30 (Table 19). The 2020 estimated SSB of 4,782 mt is below the threshold, and the stock remains in the overfished status as it was in the 2016 assessment (Table 20, Figure 32). The 2020 3-year average for *F* of 0.26 is below the threshold value thereby changing the overfishing status of the 2016 assessment to the 2020 status of not overfishing (Table 20, Figure 32).

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

Short term projections for the years 2021-2025 were run using the status quo landings from the average of the total removals from 2018 through 2020 (840 mt). The short term projection using the target *F* estimate resulted in a 15% probability of being at or below target *F* in the terminal year (Table 21, Figure 33), and a 63% probability of being at or below threshold *F*. These projections showed a 53% probability of being at or above SSB threshold in 2025 but only a 12% probability of being at target SSB (Table 21, Figure 33). The 2016 projection of 93% probability of being below threshold *F* in 2020 seemed to be met with the current estimate of *F* below the threshold. The 2020 SSB estimate just missed meeting current SSB threshold estimates bearing out the 85% probability of being at or above the SSB threshold for 2020 in the 2016 projection.

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

MRIP sampling sites have been increased for 2021 and 2022 which should result in increased sampling opportunities for recording tautog catches.

In 2016, New Jersey began conducting a ventless trap survey within and around 3 artificial reef sites off the central New Jersey coast. The trap gear is more appropriate for structure-oriented species such as tautog, and the data from this survey may potentially be useful for the next benchmark assessment if the time-series meets the minimum requirement of 10 years.
The commercial tagging program was implemented in 2020, and New Jersey's commercial fishing sector has generally been supportive. While the program has too recently been implemented to gauge its results, it is hoped the illegal market for tautog was reduced with this measure. The ability to quantify the number of fish commercially harvested will augment the current weight-only data from this fishery and increase the accuracy of its removals estimates.

List of Appendices

NJ-NYB Appendix 1: ASAPplots output of the base model
NJ-NYB Appendix 2: Retrospective adjustments and sensitivity runs

References

Atlantic States Marine Fisheries Commission. 2015. Tautog benchmark stock assessment. Arlington, VA.

Atlantic States Marine Fisheries Commission. 2016. Tautog regional stock assessment: Long Island Sound and New Jersey-New York Bight. Arlington, VA.

Atlantic States Marine Fisheries Commission. 2017. 2016 Tautog Stock Assessment Update. Arlington, VA. 143 pp.

Tables

Table 15. Total removals in metric tons by sector for the NJ-NY Bight region.

Year	Recreational Harvest	Recreational Release Mortalities	Commercial Harvest
1982	1,162.4	6.8	67.2
1983	1,579.3	13.3	45.6
1984	1,581.0	4.7	58.8
1985	2,798.7	16.7	56.9
1986	2,550.7	10.7	54.8
1987	3,404.6	39.0	58.4
1988	1,895.5	24.1	89.6
1989	1,826.0	19.9	57.9
1990	1,895.6	23.1	86.6
1991	2,767.4	66.5	93.2
1992	2,932.7	53.7	84.8
1993	1,481.2	43.3	89.2
1994	439.9	18.0	92.2
1995	1,616.0	30.3	64.1
1996	1,322.2	37.0	50.7
1997	871.9	39.1	30.9
1998	64.5	14.3	31.5
1999	769.5	77.1	26.5
2000	1,978.2	42.2	30.9
2001	1,313.3	32.6	50.3
2002	1,552.1	71.0	35.9
2003	534.4	30.2	49.5
2004	412.1	27.1	49.5
2005	170.3	10.6	47.4
2006	847.3	28.7	52.2
2007	1,087.5	62.3	58.0
2008	814.7	43.7	57.3
2009	1,241.1	48.6	34.6
2010	1,172.3	53.5	57.4
2011	762.4	49.0	66.8
2012	370.3	18.1	39.9
2013	1,277.8	134.0	52.8
2014	2,609.5	64.3	46.4
2015	820.4	75.2	47.7
2016	1,352.4	189.3	66.2
2017	868.5	82.7	64.1
2018	578.7	17.6	50.0
2019	900.9	84.6	66.3
2020	643.4	147.0	32.1

Table 16. Indices used in the ASAP model for the NJ-NYB region.

Index Name	Index Metric	Design	Time of Year	Years	Ages
NY DEC Western Long Island Seine Survey	Mean number per haul	Fixed	May-Oct	1984-2020	YOY
NJ DEP Ocean Trawl Survey	Mean number per tow	Stratified Random	Jan-Oct	1989-2019	1+
MRIP CPUE	Total catch per angler-trip	Stratified Random	Mar-Dec	1981-2020	1+

Table 17. Model structure and life history information used in the stock assessment.

	Value(s)
Years in Model	1989-2020
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%
Fraction of year before SSB clculation	0.42
Number of selectivity blocks	5
Selectivity periods	1989-1996, 1997- 2006, 2007-2011, 2012-2017, and 2018-2020
Selectivity type	Single logistic

	Age Group											
	1	2	3	4	5	6	7	8	9	10	11	12+
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 18. Spawning stock biomass, recruitment, annual *F*, and 3-year average *F* estimates for the NJ-NY Bight region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual *F*	3-year Average *F*
1989	9,206	3.91	0.29	
1990	9,408	3.54	0.30	
1991	8,633	3.44	0.49	0.36
1992	6,738	2.58	0.72	0.50
1993	5,517	2.04	0.47	0.56
1994	5,428	1.62	0.20	0.46
1995	5,262	1.40	0.39	0.35
1996	4,599	1.25	0.35	0.31
1997	4,230	1.38	0.23	0.32
1998	4,293	1.85	0.09	0.22
1999	4,502	1.52	0.20	0.17
2000	4,457	1.46	0.35	0.21
2001	4,124	1.52	0.42	0.32
2002	3,683	1.38	0.51	0.42
2003	3,511	1.41	0.27	0.40
2004	3,649	1.85	0.18	0.32
2005	3,921	1.91	0.10	0.18
2006	4,241	1.91	0.24	0.17
2007	4,232	1.88	0.33	0.22
2008	4,133	1.86	0.32	0.30
2009	3,963	1.42	0.42	0.36
2010	3,665	1.57	0.45	0.40
2011	3,442	1.56	0.31	0.39
2012	3,565	2.19	0.22	0.32
2013	3,645	2.10	0.40	0.31
2014	3,615	2.20	0.52	0.38
2015	3,674	2.05	0.42	0.44
2016	3,779	1.92	0.53	0.49
2017	3,867	1.60	0.39	0.45
2018	4,150	2.46	0.25	0.39
2019	4,373	1.35	0.28	0.31
2020	4,782	1.41	0.23	0.26

Table 19. Comparison of spawning stock biomass and fishing mortality reference points from 2016 and 2021 updates for the NJ-NYB region.

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
2016 Update	3,154	2,351	0.20	0.34
2021 Update	6,552	4,890	0.19	0.30

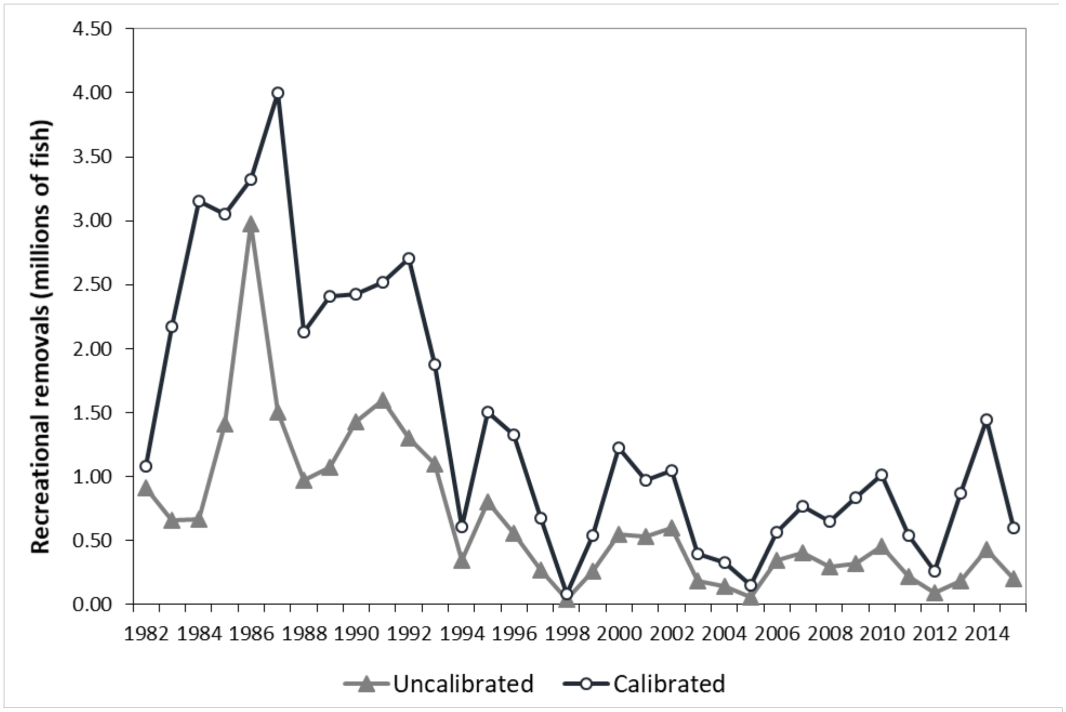
Table 20. Stock status for the NJ-NYB region.

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
Reference Points	6,552	4,890	0.19	0.30
2020 Estimate	4,782		0.26	
2020 Status	Overfished		Not Overfishing	

Table 21. Short-term projections for the NJ-NYB region using status quo landings

Landings (mt) for 2021-2025	Probability of being at or below *F* Target in 5 years	Probability of being at or above SSB threshold in 5 years
Status quo (2018-2020 average)	15%	53%

Figures



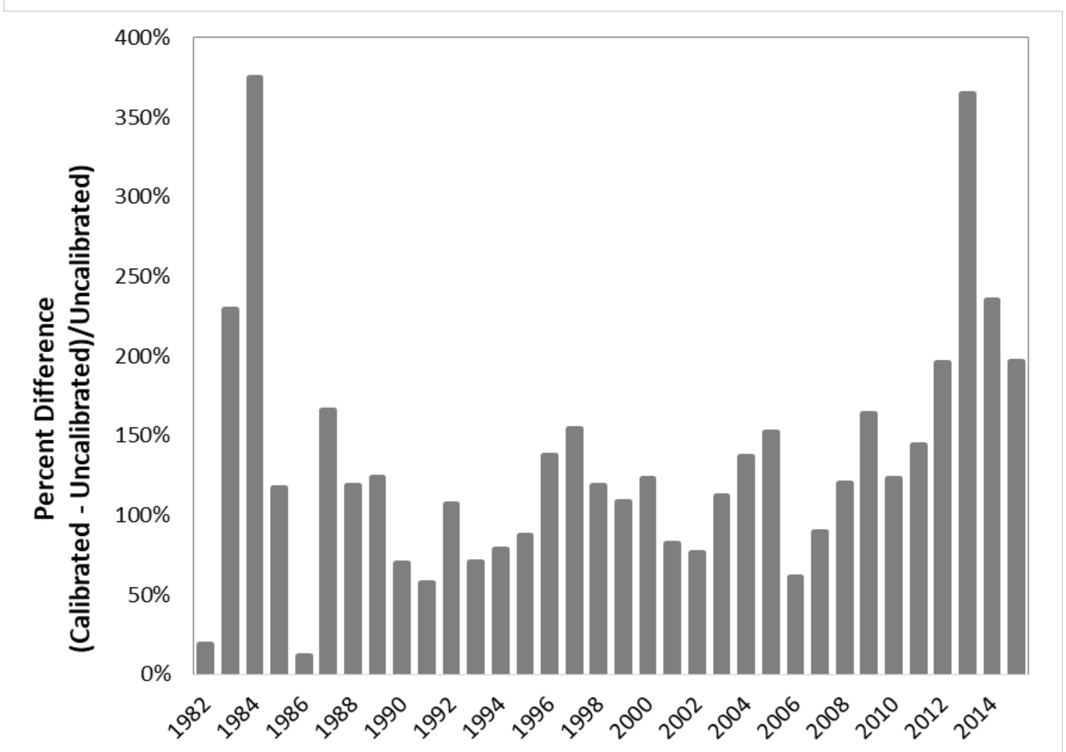


Figure 23. Comparison of calibrated and uncalibrated recreational removals (harvest + release mortalities) in numbers of fish (top) and percent difference (bottom) for the NJ-NY Bight region.

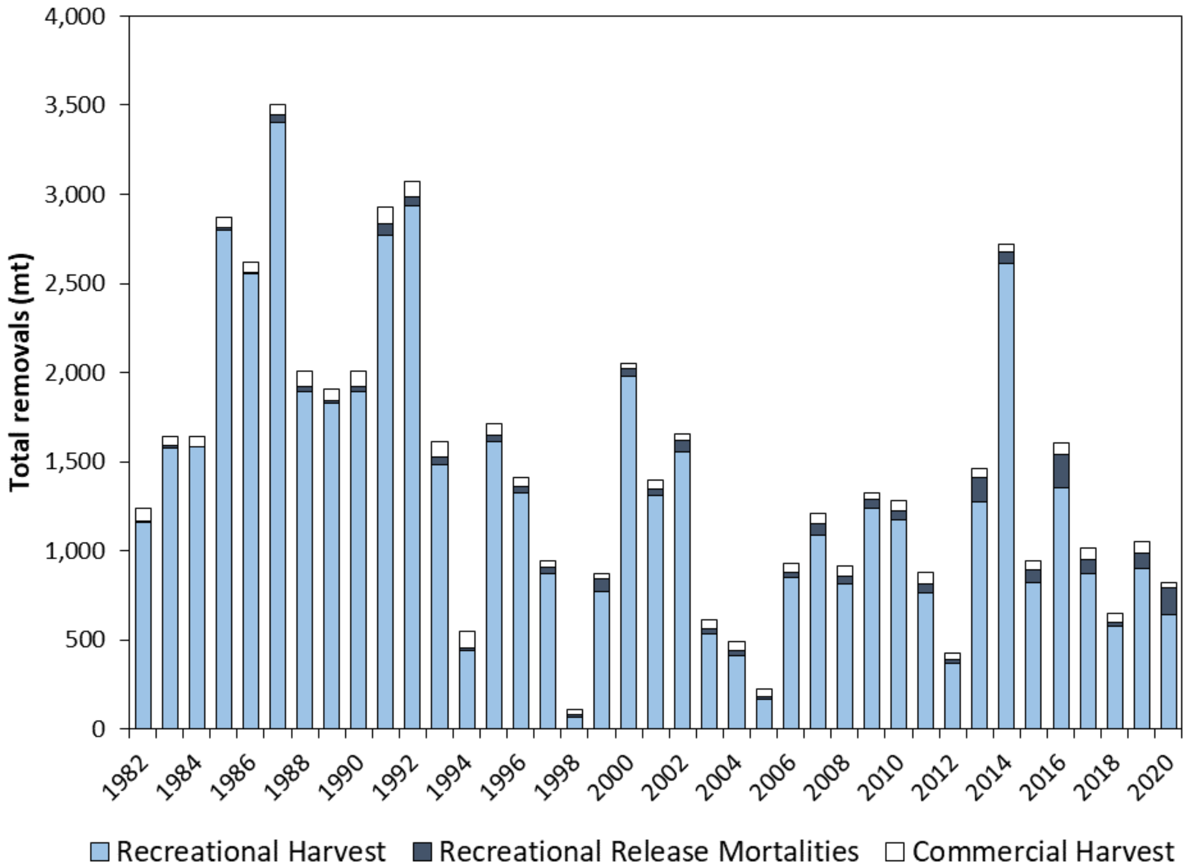


Figure 24. Total removals by sector for NJ-NY Bight region.

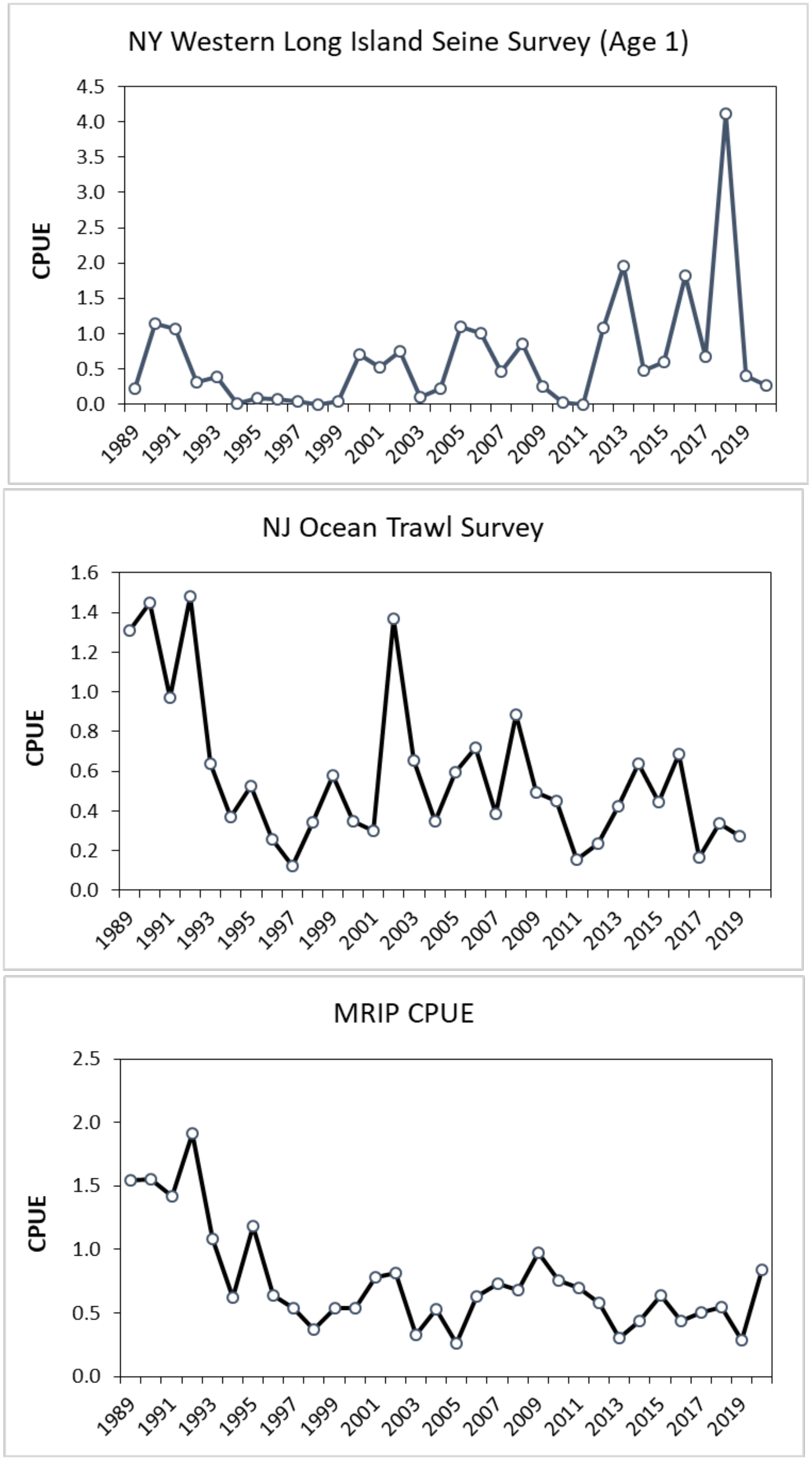


Figure 25. Indices of abundance used for the NJ-NY Bight region.

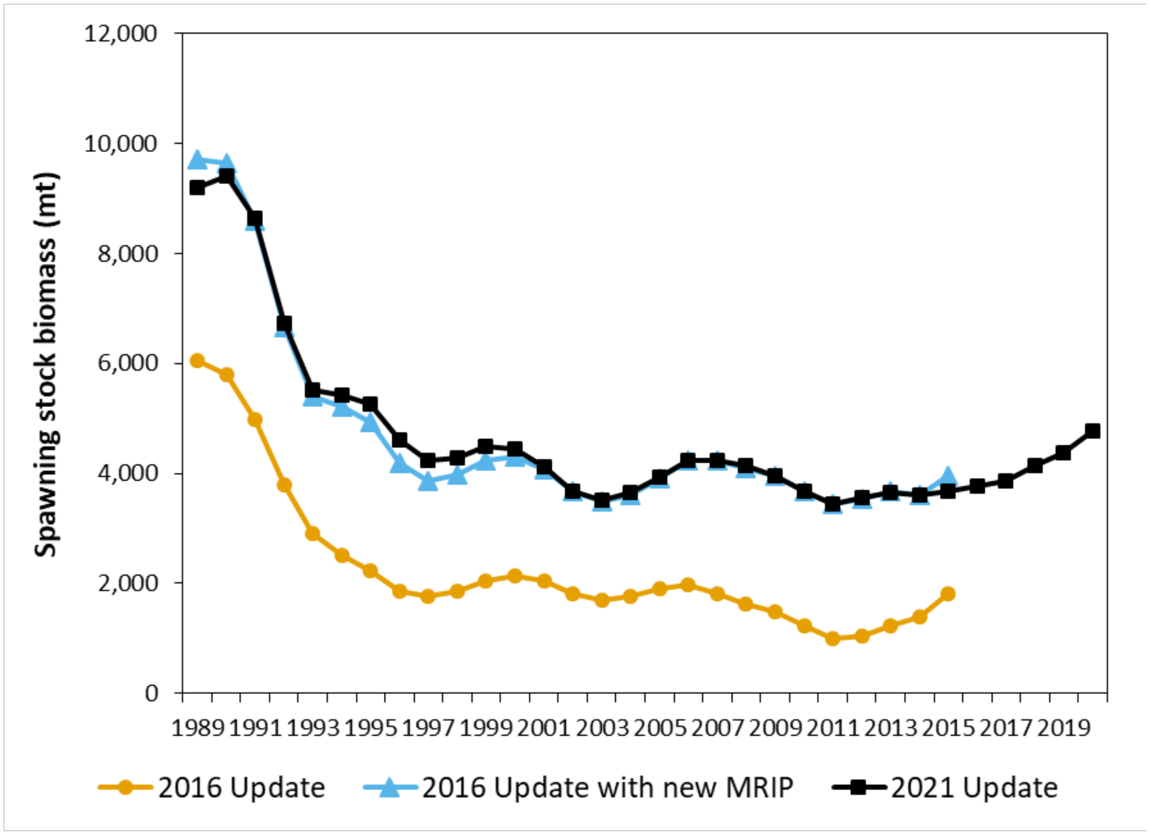


Figure 26. Estimates of spawning stock biomass for the NJ-NYB region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

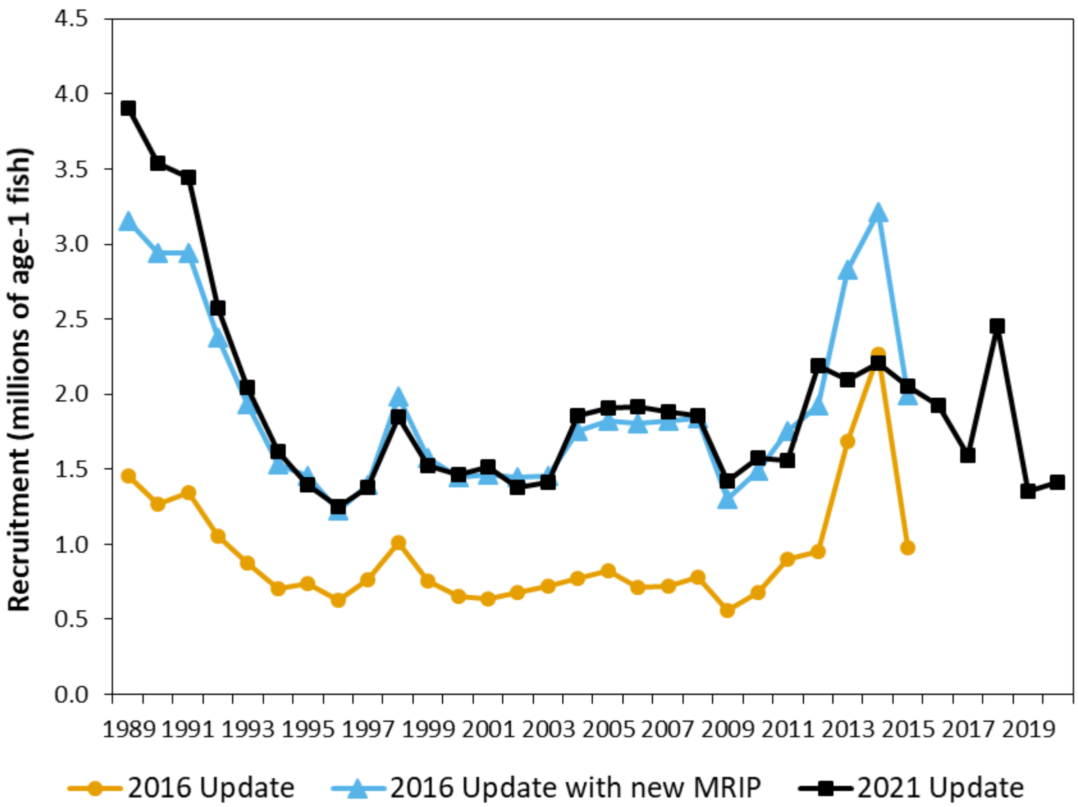


Figure 27. Estimates of recruitment for the NJ-NYB region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

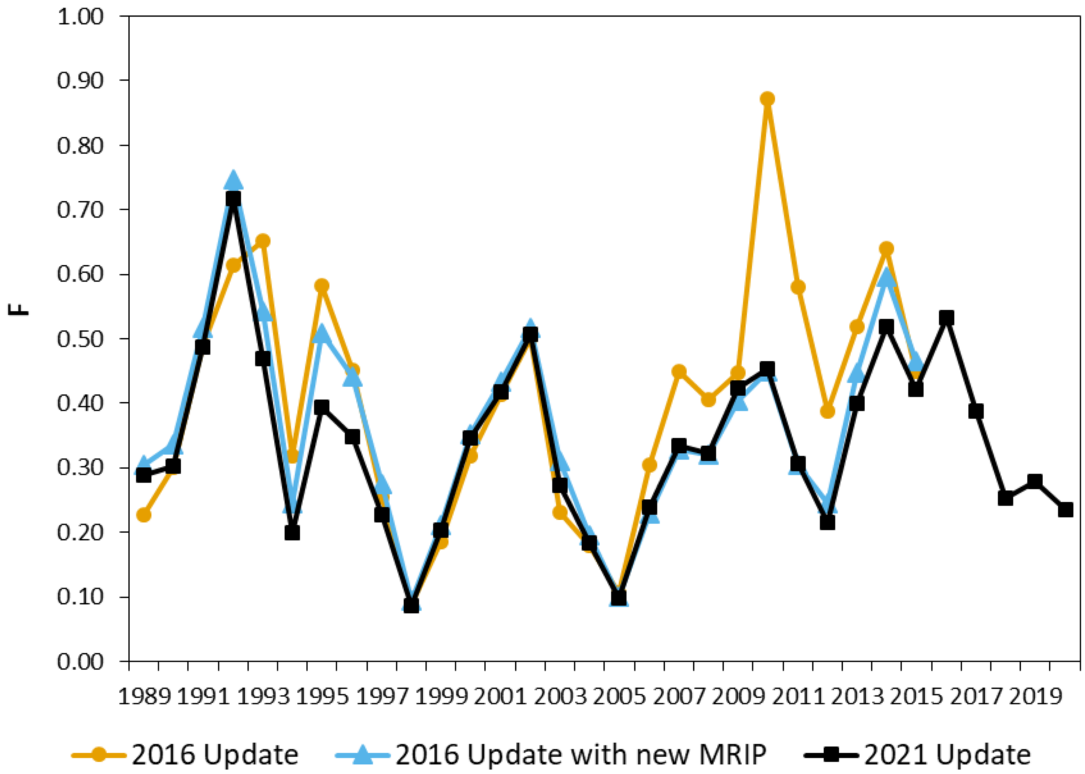
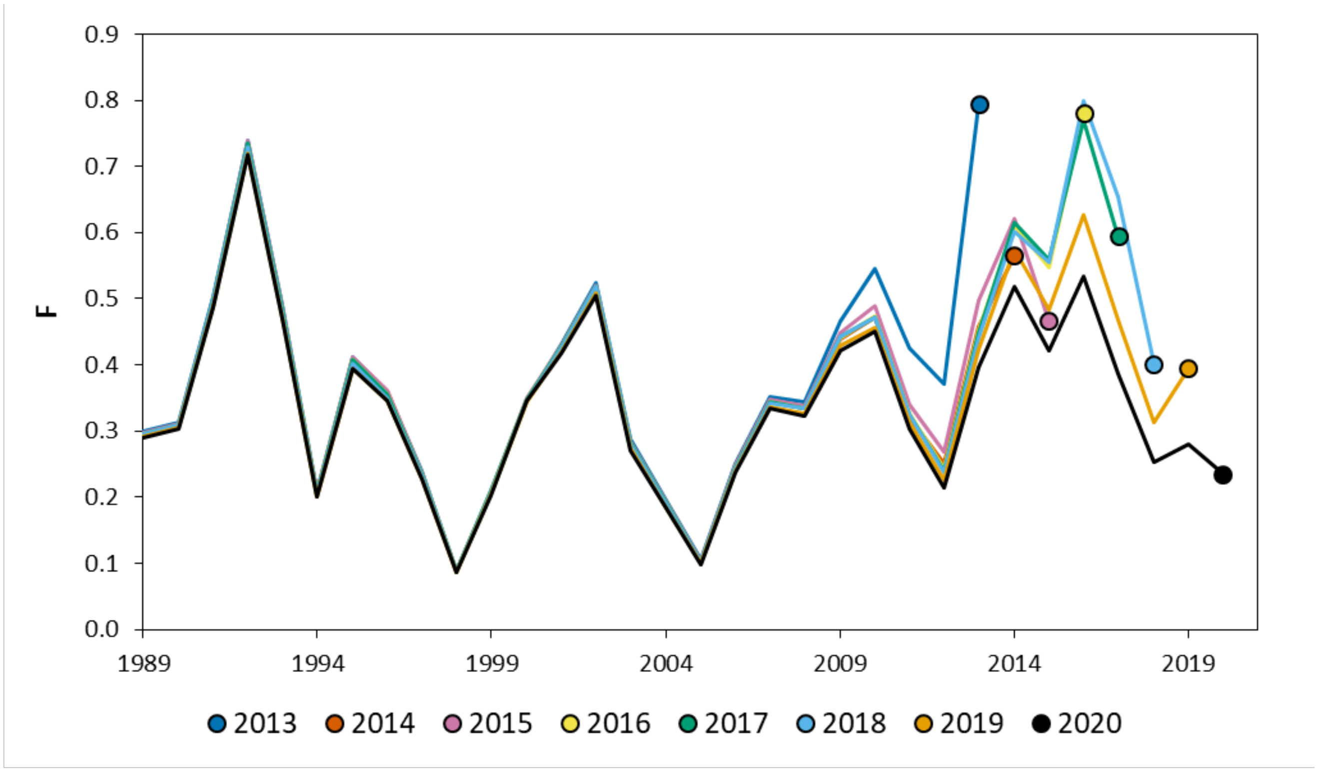


Figure 28. Estimates of the annual full *F* for NJ-NYB region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.



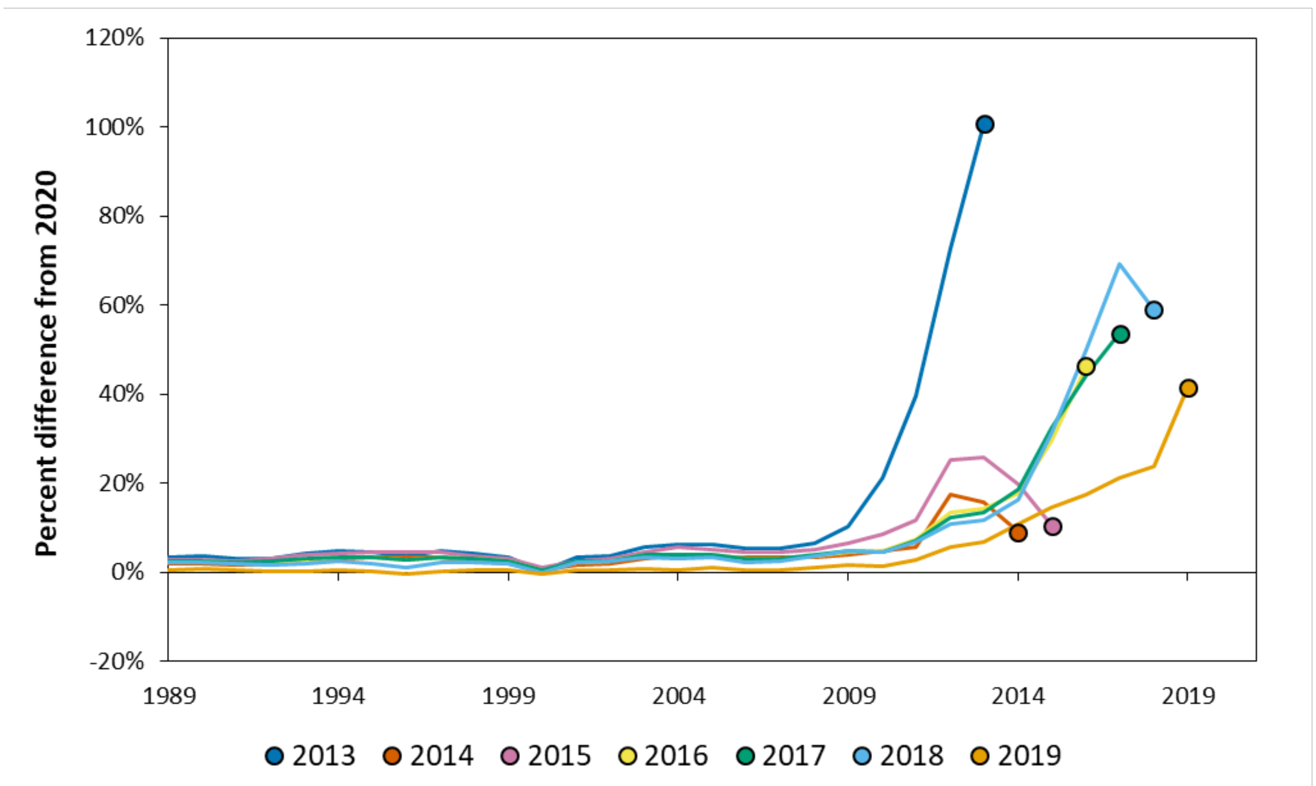


Figure 29. Retrospective analysis for annual *F* from the NJ-NYB region in absolute numbers (top) and percent difference (bottom).

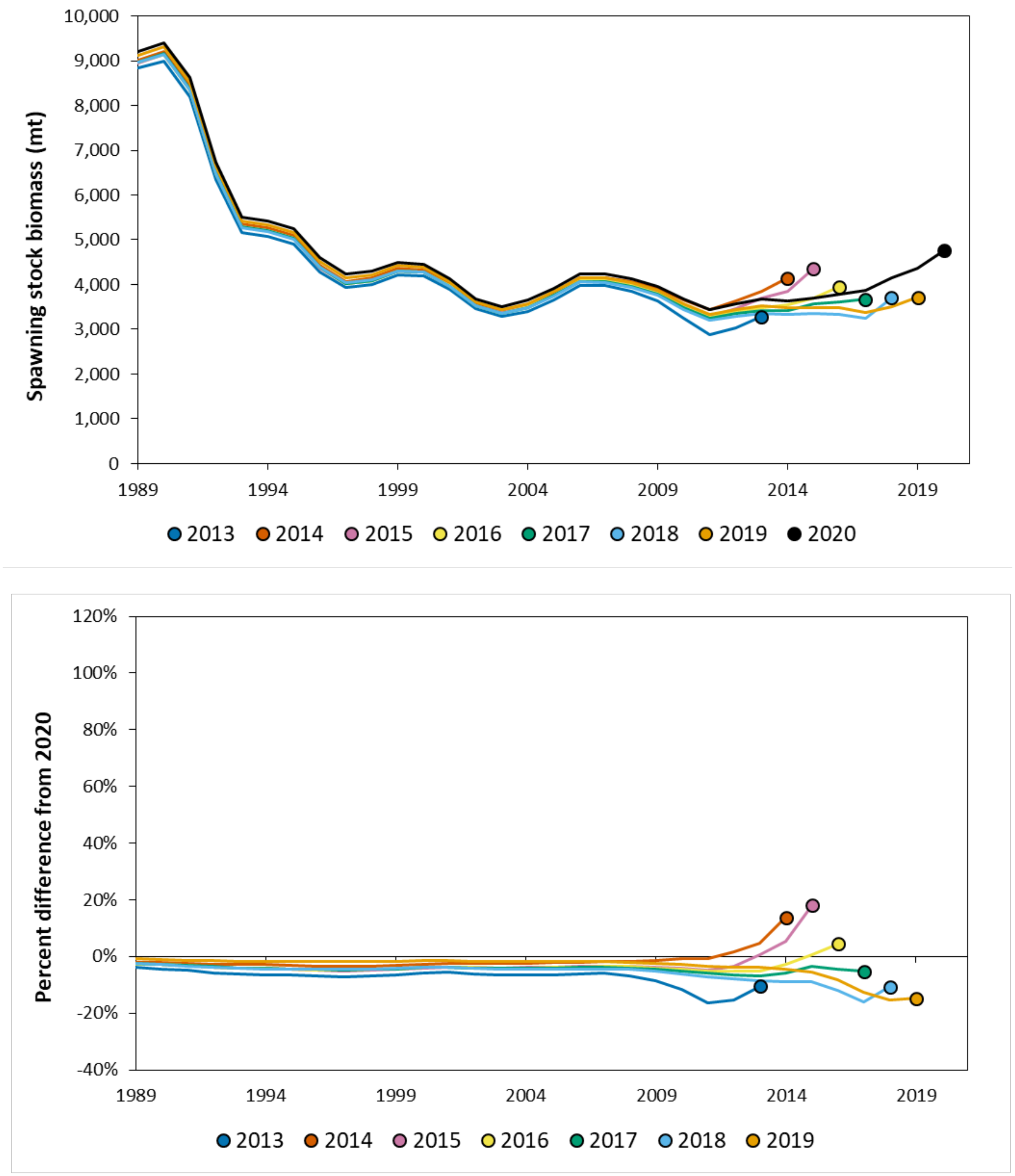
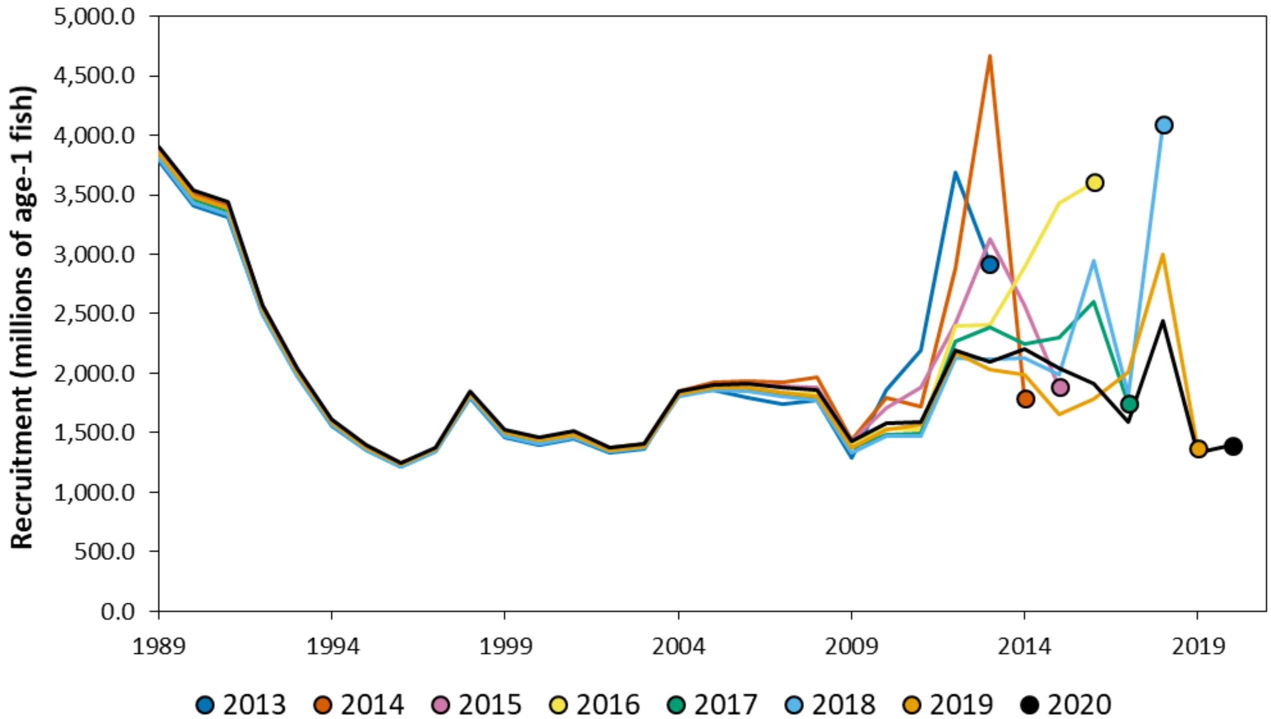


Figure 30. Retrospective analysis for annual SSB from the NJ-NYB region in absolute numbers (top) and percent difference (bottom).



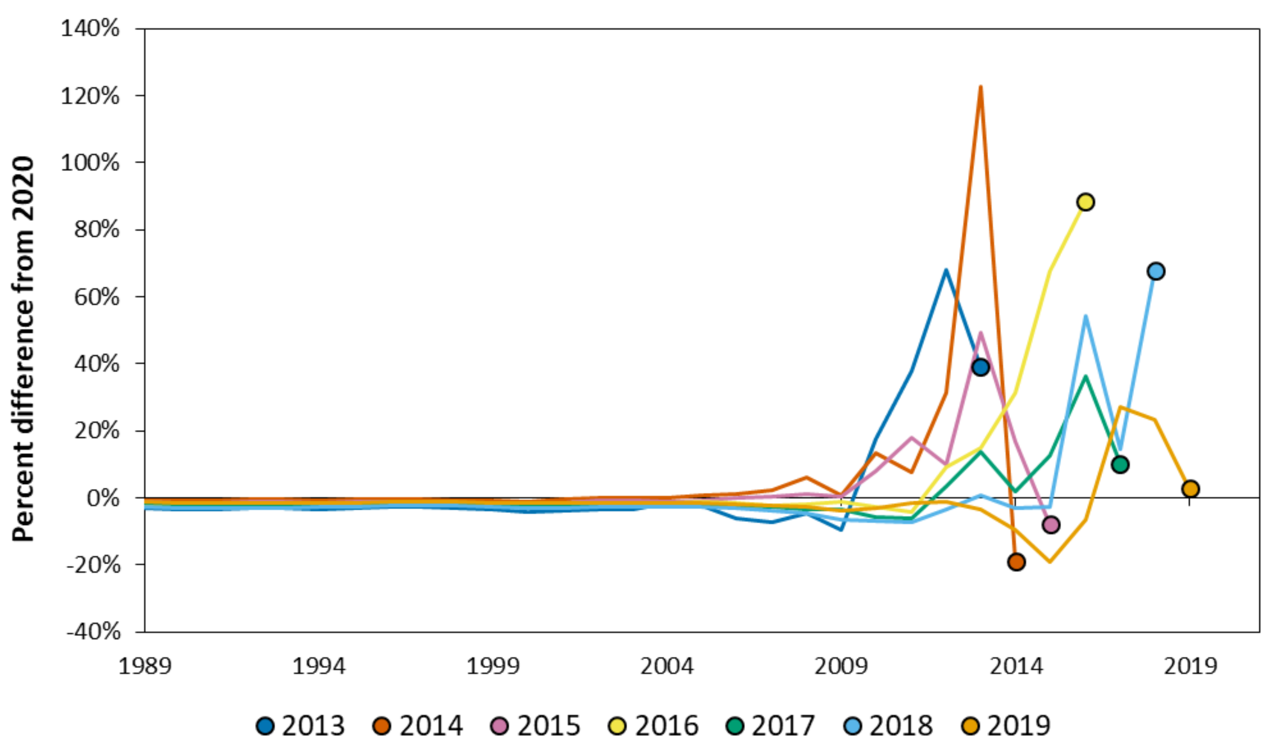
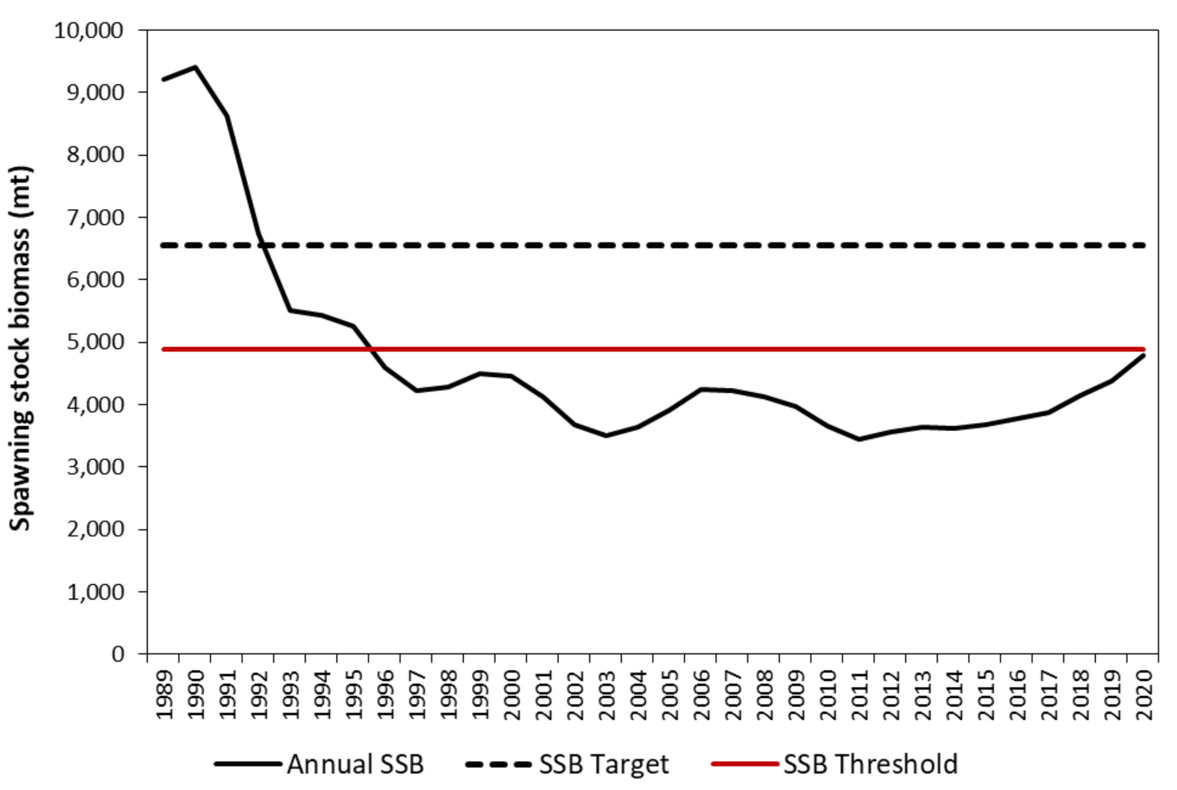


Figure 31. Retrospective analysis for annual recruitment from the NJ-NYB region in absolute numbers (top) and percent difference (bottom).



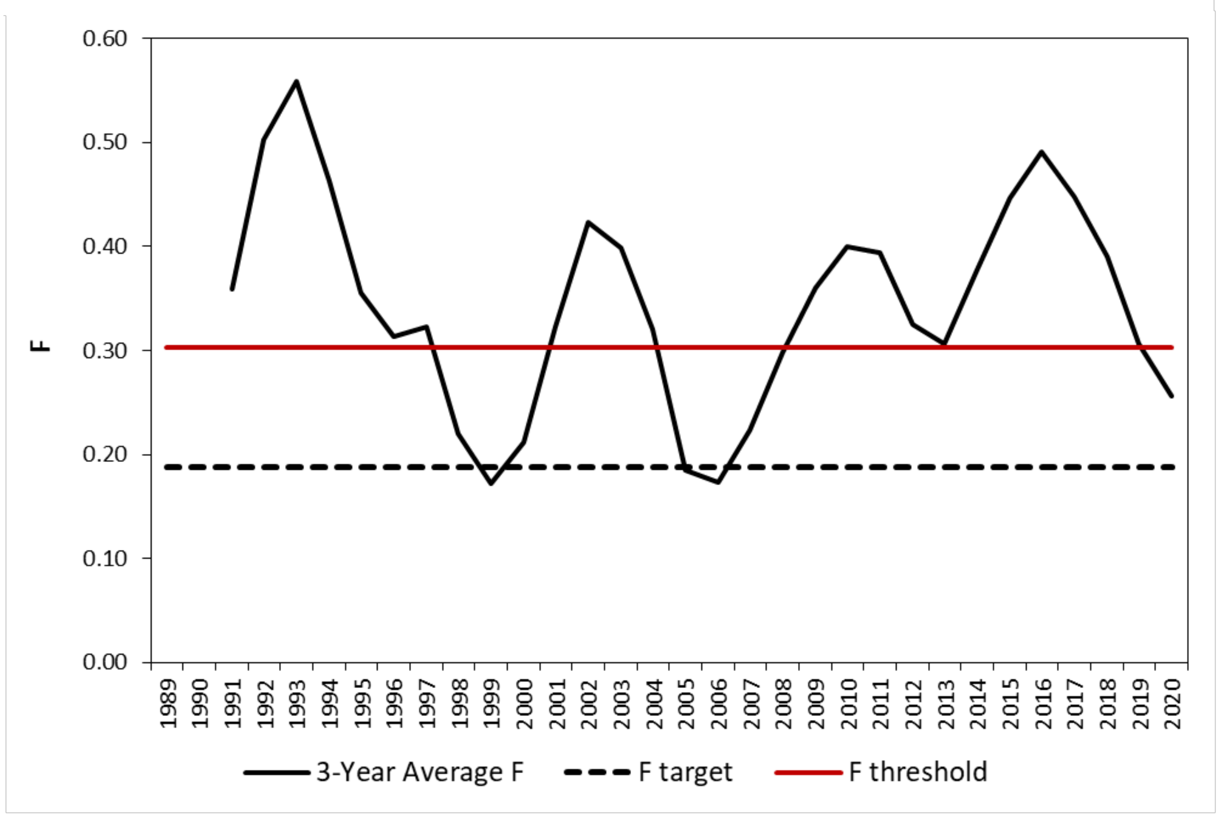


Figure 32. Annual SSB plotted with SSB target and threshold (top) and 3-year average *F* plotted with *F* target and threshold (bottom) for the NJ-NYB region.

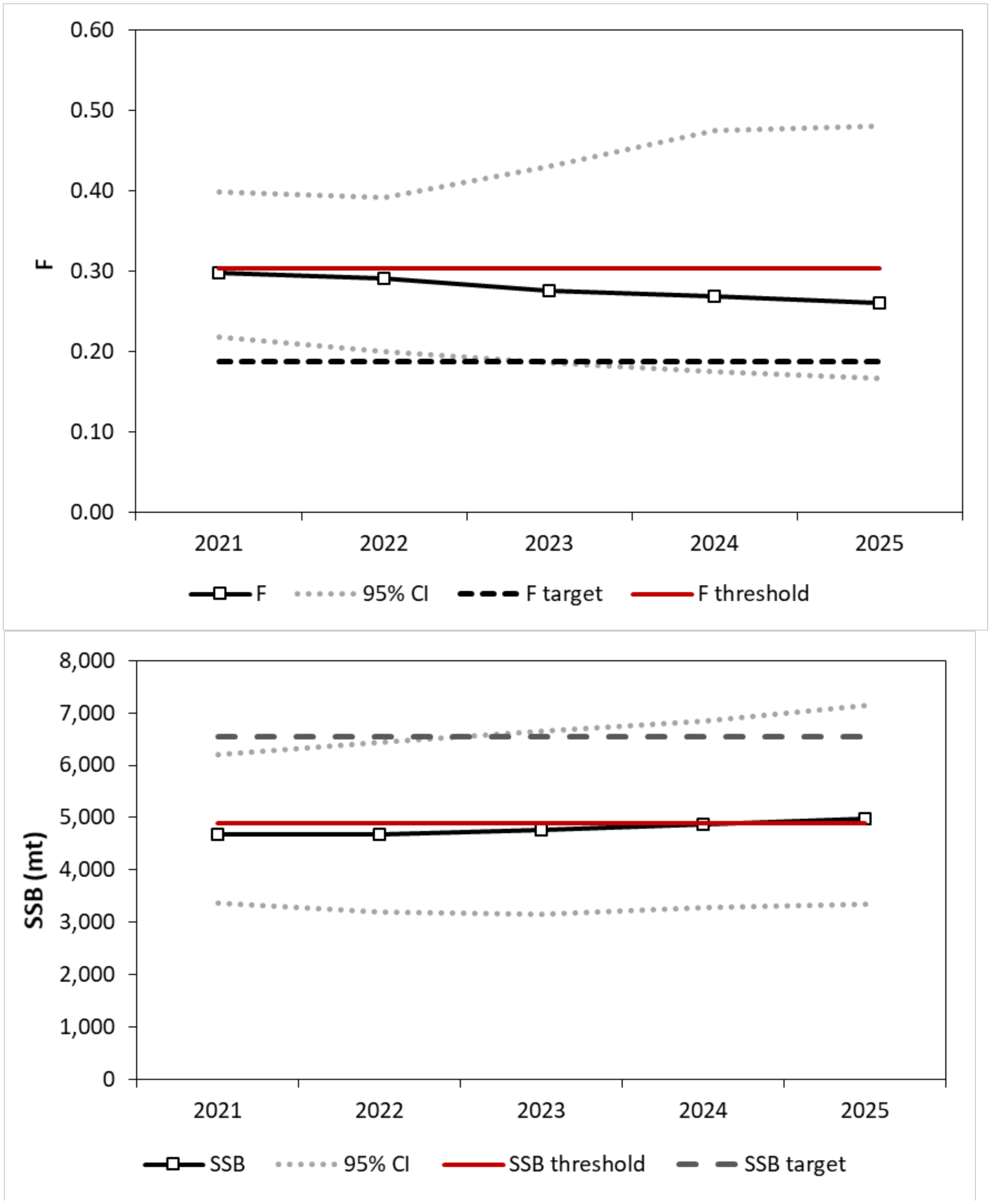


Figure 33. Status quo harvest projections for the NJ-NY Bight region showing the trajectory of annual *F* (top) and SSB (bottom) with their target and threshold reference points. Dotted grey lines indicate the 95% confidence intervals of the estimates.

Tautog Stock Assessment Update
DELAWARE-MARYLAND-VIRGINIA REGION
2021

Executive Summary
This stock assessment is an update to the existing benchmark assessment for tautog (ASMFC 2015, ASMFC 2016); the previous assessment update was completed in 2017 (ASMFC 2017). This assessment updates the accepted statistical catch-at-age model with commercial and recreational fishery catch data and indices of relative abundance from fishery-independent and fishery-dependent data sources through the terminal year of 2020.

In the Delaware-Maryland-Virginia (DMV) region, the stock was not overfished and overfishing was not occurring in 2020.

This update includes the new time-series of calibrated recreational data from the Marine Recreational Information Program (MRIP). For the DMV region, the calibrated estimates were on average 138% higher than the uncalibrated estimates over the entire time series. The new MRIP estimates resulted in higher estimates of SSB and recruitment, but had less of an impact on *F*. Stock status has changed in this region since the last assessment update: the DMV region is no longer overfished or experiencing overfishing. This appears to be related to reductions in *F* and increases in SSB in the most recent few years, as opposed to an artifact of the new MRIP numbers.

Short term projections using the average landings from the last three years found that the probability of the fully-recruited *F* being at or below the F target is expected to be 100% in 2025 and for every year of the projections. The probability of SSB being at or above SSB threshold is also equal to 100% in 2025 and for every year of the projection.

TOR 1. Update fishery-dependent data (landings, discards, catch-at-age, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.
Recreational landings were obtained from the NMFS MRIP data collection program. In 2018 MRIP changed the method of estimating fishing effort by introducing mail-based fishing effort survey (FES) and eliminating Coastal Household Telephone Survey (CHTS). This change resulted in significant increases in the estimates of the recreational harvest and discards, with calibrated estimates of removals averaging 138% higher than uncalibrated estimates (Figure 34).

Recreational harvest (A+B1) of tautog for DMV region in 1982 - 2020 varied between 35 thousand and 1.1 million of fish, with the overall declining trend through time (Table 22, Figure 35). There is an overall declining trend in recreational harvest, most likely a reflection of the protective regulatory measures (minimum size increase, bag size reduction and seasonal closures) instituted to reduce fishing mortality. Average recreational harvest for the most recent five year period (2016-2020) was 80.9 thousand fish, while the estimated harvest in 2018 was the lowest on record – 35.4 thousand fish.

Estimated recreational releases have varied from 15.6 thousand fish in 1984 to 2.55 million fish in 2010. Assuming 2.5% release mortality rate, dead releases varied from 391 to 63.75 thousand fish (Table 22, Figure 35). There was a general increasing trend for recreational releases through time. However, release mortality losses generally were very small relative to the harvest, thus the total recreational losses (A+B1+B2) are only slightly above the recreational harvest (A+B1) as reflected in Figure 35.

Due to low number of intercepted fishing trips that had tautog in recent decade, annual estimates of recreational landings and discards in MD and VA had low precision; Proportional Standard Error (PSE) values exceeded 50% in about half of the most recent years PSEs were mostly below 50% in Delaware.

Commercial landings reported by each state (DE, MD, and VA) were updated through 2020 and combined to derive region specific landings. Historically commercial landings peaked at 31.4 thousand pounds (14.2 mt) in 1997 and were in continuous decline ever since (Table 22, Figure 35). Average commercial landings for 2016 - 2020 were 4,363 pounds (1.98 mt). Data on commercial discards were not available, but discards are believed to be minimal. Therefore, estimates of dead discards were not generated.

TOR 2. Update fishery-independent data (abundance indices, age-length data, etc.) that were used in the previous peer-reviewed and accepted benchmark stock assessment.

There are no fishery independent indices available for the DMV region. The only index of relative abundance used in the 2013 benchmark assessment and 2016 assessment update was catch per trip derived from MRIP data (Table 23). Total catch per trip was modeled with GLM method using a suite of potentially important covariates (year, state, wave, and mode) with an effort offset based on angler hours for the trip. The MRIP based index was updated through 2020. The MRIP index in 2016-2020 reverted a declining trend and was relatively stable in recent years (Figure 36).

Biological sampling for tautog is conducted by each state on annual basis with the goal to collect at least 200 samples per year for each state. Samples for length, weight, sex and age are taken mostly by intercepting the catch of recreational fishermen. However, some samples were taken from commercial fishery as well. Annual age length keys were constructed by combining paired length - age samples from all three states. Age length keys were constructed for years 2016 - 2020 to update age information since 2016 assessment update that had a 2015 terminal year. On average, 462 samples of age and size samples per years were used to construct annual ALKs for 2016 - 2020, covering 22 - 78 cm size range and ages 2 - 28.

Length frequency of the recreational harvest was characterized using length frequency of the data collected by MRIP for each state. State specific MRIP annual harvest estimates were applied to corresponding length frequency of the recreational harvest (A+B1) to obtain harvest in numbers by size. Size frequency of discards (B2) was characterized by combining the MRIP Type 9 and ALS raw data on the size of released fish by state. State specific data were pooled to obtain regional estimate of total harvest (A+B1) and discards.

Due to low or absent commercial fishery size sampling, size frequency of recreational harvest was used to describe commercial catch at size. State-specific recreational harvest, dead releases, and commercial harvest in numbers of fish by size were combined into a total regional estimate and converted into catch at age using regional year-specific age-length keys.

TOR 3. Tabulate or list the life history information used in the assessment and/or model parameterization (*M*, age plus group, start year, maturity, sex ratio, etc.) and note any differences (e.g., new selectivity block, revised *M* value) from benchmark.

Model structure and life history parameters used in the assessment for DMV region are presented in Table 24. Natural mortality was assumed to be a constant value for all ages M=0.16 as estimated in the 2015 benchmark assessment. Tautog were considered to be immature through age 2, 78% mature at age 3, 97% mature at age 4 and 100% mature at age 5. Sex ratio was assumed to be 50:50 and no sexual dimorphism in growth was considered.

ASAP model was run from 1990 to 2020 based on the catch at age and MRIP index data representing ages 1 - 12, where age 12 was treated as a plus group. Removals were modeled as a single fleet that included total removals in weight and numbers-at-age from recreational harvest, recreational release mortality, and commercial catch. Selectivity of the fleet was described by a single logistic curve. Four selectivity blocks were used: 1982-1996, 1997- 2006, 2007-2011 and 20012 - 2020. The number of selectivity blocks and their definition was similar to the 2016 assessment updated, except that the fourth block was extended through 2020. Breaks were chosen based on implementation of fishery regulations. Adult indices were fit to index-at-age data assuming a single logistic selectivity curve and constant catchability. No YOY indices are available for DMV region.

All likelihood components weights (lambda values) were retained from the 2015 benchmark assessment and 2016 assessment update. Annual CVs on total catch were set equal to the weighted mean of state specific MRIP PSE values, while index CVs were based on the GLM-standardized CVs and adjusted upwards to bring their RMSE values close to one. The input effective sample size (ESS) was set equal to the number of tautog trips intercepted by the MRIP. ESS values were further adjusted during second model run using ASAP's estimates of stage 2 multipliers for multinomials.

TOR 4. Update accepted model(s) or trend analyses and estimate uncertainty. Include sensitivity runs and retrospective analysis if possible and compare with the benchmark assessment results. Include bridge runs to sequentially document each change from the previously accepted model to the updated model.

The previous assessment update completed in 2016 was based on the ASAP model run from 1990 to 2015. To evaluate the effect of new estimates, a bridge run was completed with new MRIP removals estimates for 1990 – 2015 using the same model inputs as in 2016 assessment update, with the exception of the total catch and the catch-at-age matrix, which was modified according to the new MRIP estimates. As expected, higher estimates of recreational catch from recalibrated MRIP survey resulted in higher estimates of numbers at age, recruitment, total and spawning biomass (Figure 37 and Figure 38; DMV Appendix 1). New fishing mortality estimates were slightly lower than in 2016 assessment update for the first half of the time series, and then switched to being slightly higher than in 2016 assessment for the second half of the time series (Figure 39). However, the trend in both cases was very similar (Figure 39). The overall scale of estimated fishing mortality has not changed. The assessment model inputs were further updated through 2020 and model was run with the inputs and parameters as described in TOR3.

Retrospective analyses were performed by shortening the data time series by one year at a time and comparing the results to the output of the model with full time series (1990-2020). The analysis was completed for time series ending in 2014 (a seven-year peel).

As in the 2015 benchmark assessment and 2016 assessment update, the DMV region showed a strong retrospective pattern, consistently underestimating *F* (16% or less, Figure 40) and overestimating SSB (120% in 2014, about 40% in 2015-2017, Figure 41). Retrospective bias in *F* and SSB in this assessment update appears to be smaller than estimated before in 2015. Bias in recruitment was not unidirectional; both over and underestimation have occurred. The level of bias ranged from 10 to 115% (Figure 42). The estimates of recruitment, *F* and SSB produced by different runs converged when going back in time. Terminal year estimates of SSB and *F* were still within the confidence intervals of the model estimates when corrected for retrospective bias (DMV Appendix 2 Figure A2.1), so a retrospective adjustment was not performed.

A limited number of sensitivity runs were conducted to examine the effects of input data and model configuration on model performance and results.

The base model results were insensitive to changes in starting values of model parameters (initial numbers at age, steepness, selectivity, catchability, etc). The model was converging on the same parameters estimates, within a range of initial starting values, indicating stability of model solution. Fixing steepness parameter at 1, thus assuming no stock recruitment relationship, had very little effect on the final model results.

Unlike other regions, no sensitivity runs were completed to explore the effect of the specific index of abundance and the effect of imputed data on MRIP index and model results. There is only one index available for the region (MRIP CPUE), therefore removal of the index was not possible. The MRIP survey schedule was not significantly affected by the COVID pandemic in 2020 in this region. Consequently, MRIP index calculated using imputed data was nearly identical to the one that used only collected information. The index based on the imputed data was consistently higher by 3-4% relative to index based on non - imputed information. Hence, comparison was not needed as it would produce identical results.

The most influential parameters to the model were coefficients of variation (CVs) of the index of abundance and catch. Smaller values of CV force the model to fit predicted values of index or total catch closer to the observed and vice versa. To investigate the role of the precision of the estimate of index (MRIP CV), the model was run with the range of estimates of CVs (beginning with the original estimates and following with the CVs increased two, three, four and five fold), resulting in five different CV vectors. Results indicated that overall model fit (objective function value) improves with the increase in CV index and the RMSE approaches desired value of 1 when CVs are inflated lose 4.5 times, the overall differences in terminal values of SSB and in particular, *F* were insignificant (DMV Appendix 2 Figure A2.2). However, there are more substantial differences between SSB and *F* values in earlier part of time series, but the overall trend in SSB and *F* persisted (Figure 10).

The 2016 assessment update applied a 1.3 inflation factor to the catch CV to account for some unreported catch. A comparison of model runs with the catch CV as estimated by MRIP versus the inflated CV option demonstrated no appreciable change in estimated *F* or SSB (DMV Appendix 2 Figure A2.3). Overall, the model estimates appear to be stable and not sensitive to changes explored in various sensitivity runs.

As in the benchmark and 2016 assessments, there was a high peak in fishing mortality in 2010-2012 caused by high recreational harvest estimates for these years. Fishing mortality has been continuously declining since then, likely due to a series management actions, designed to reduce removals. Fishing mortality has been below the target since 2015 (Table 25, Figure 43). The terminal year (2020) *F* was estimated at 0.09, while the three-year average for 2018 – 2020 was estimated as 0.06 (Table 25).

Spawning stock biomass went through two stages of decline during 1990-2010 (Table 25, Figure 5). SSB has been increasing since 2012, following reductions in removals, crossed the SSB threshold in 2018 and nearly approached the SSB target in the terminal year 2020 (Table 25, Figure 5). Total abundance declined from a stable level of about 5 million fish in 1998 - 2008 period to the lowest level of 2.9 million fish in 2013. Total abundance was increasing since 2013 and reached the level of early 2000s by 2020 (5.1 million).

Except for the single spike at the beginning of the time series, recruitment appears to have been relatively stable, varying within the range of 0.5-1.5 million fish with an average near 1 million fish (Table 25, Figure 38). No outstanding year classes were noted aside of the 1990 year class (age-1 in 1991 on Figure 38). Overall, recruitment has exhibited low variability and lack of sharp inter-annual changes.

TOR 5. Update the biological reference points or trend-based indicators/metrics for the stock. Determine stock status.

Overfishing status was evaluated based on average *F* from 2018-2020. Annual estimates of *F* are highly variable due to the annual variability in estimated catch due to the imprecision of the MRIP estimates. Therefore, the assessment update employed the three-year running average to evaluate overfishing status to smooth out the inter-annual variability in *F* and allow management to respond to genuine trends. Overfished status is determined by SSB in the terminal year of the assessment (2020). Estimates of SSB are more stable, so the terminal year estimate is considered to be appropriate to determine overfished status.

Stock-recruitment relationship for the DMV region was considered to be unreliable by the 2013 benchmark assessment. Therefore, SPR-based reference points were used for *F* reference points. Specifically, F40% was selected as a target reference point and F30% as a threshold. To calculate corresponding target and threshold level of SSB, the projection model AGEPRO was used to project the population forward in time under constant fishing mortality ($F_{30\%SPR}$ and $F_{40\%SPR}$) with recruitment drawn from the model estimated time-series of observed recruitment to develop an estimate of the long-term equilibrium SSB associated with those fishing mortality reference points.

The 2021 update resulted in slightly different values of *F* reference points $F_{40\%SPR}$ = 0.17, and $F_{threshold}$ = 0.27 (Table 26). These slight changes are a result of re-estimation of age specific selectivity for the latest selectivity block (2012-2020). The three-year average *F* from 2018-2020 was 0.09, below both the target and the threshold, indicating overfishing is not occurring (Table 27, Figure 43).

New estimates for SSB target and threshold were higher than estimated during the benchmark, at 4,488 and 3,355 mt, respectively (Table 26). Terminal year SSB estimate was 4,382 mt, slightly below the target but above the threshold (Table 27, Figure 43). According to the probability distribution of SSB estimates based on the MCMC analysis, there is 99% chance that SSB in 2020 was above $SSB_{threshold}$, indicating the stock is not overfished.

TOR 6. Conduct short term projections when appropriate. Discuss assumptions if different from the benchmark and describe alternate runs.

Short term (2021-2025) projection scenario to determine status of the stock and trends in SSB and *F* assuming constant harvest level equal to the recent three year average (2018-2020) was completed using AgePro (v. 4.2, NOAA Fisheries Toolbox) model. Biological parameters (maturity, M, weights at age) for the projection model were the same used in the ASAP population model, with the exception that projection catch weights at age were set equal to the average catch weight at age in the most recent selectivity block. Recruitment for the projected years was drawn from the vector of recruitment values estimated by ASAP model in 2021 assessment update. Fishery selectivity at age was set equal to the one estimated by ASAP for the most recent selectivity period. Harvest for the projected period was assumed equal to the most recent three-year average harvest.

If the constant catch of 155.47 mt is maintained during 2021-2025 (status quo scenario), the probability of the fully-recruited *F* being at or below the F target is expected to be 100% within each year of the projection. The probability of SSB being at or above SSB threshold is also equal to 100 % (Table 28, Figure 44). Fishing mortality is projected to be low (0.03 to 0.04), while SSB is projected to grow and exceed the target in 2021 (Figure 44).

TOR 7. Comment on research recommendations from the benchmark stock assessment and note which have been addressed or initiated. Indicate which improvements should be made before the stock undergoes a benchmark assessment.

Developing a fishery independent index for tautog in the DMV is a high priority research recommendation. Since the last benchmark, MD DNR has started a seagrass survey that has the potential to serve as a YOY index for tautog. The SAS recommends that this survey be continued and considered for use in the next benchmark.

List of Appendices

DMV Appendix 1: ASAPplots output of the base model
DMV Appendix 2: Retrospective adjustments and sensitivity runs

References

Atlantic States Marine Fisheries Commission. 2015. Tautog benchmark stock assessment. Arlington, VA.

Atlantic States Marine Fisheries Commission. 2016. Tautog regional stock assessment: Long Island Sound and New Jersey-New York Bight. Arlington, VA.

Atlantic States Marine Fisheries Commission. 2017. 2016 Tautog Stock Assessment Update. Arlington, VA. 143 pp.

Tables

Table 22. Total removals in metric tons by sector for the DMV region.

Year	Recreational Harvest	Recreational Release Mortalities	Commercial Harvest
1982	1,110.8	0.8	
1983	1,266.9	4.5	
1984	1,158.6	0.4	
1985	927.9	9.5	3.0
1986	1,093.1	3.6	2.3
1987	1,068.5	3.5	3.4
1988	665.1	3.4	4.3
1989	1,758.8	7.5	5.5
1990	532.1	9.5	4.3
1991	1,126.8	14.5	4.3
1992	652.9	13.5	4.3
1993	1,429.3	21.5	3.1
1994	1,249.3	16.5	6.1
1995	1,662.0	21.1	14.1
1996	1,373.5	10.9	13.8
1997	717.8	13.1	14.2
1998	771.9	24.7	10.0
1999	677.5	27.0	12.5
2000	496.7	27.4	8.5
2001	261.9	17.2	8.4
2002	669.1	22.8	12.7
2003	449.8	20.3	8.4
2004	1,010.9	36.7	9.7
2005	539.4	29.2	5.5
2006	709.2	30.8	7.0
2007	676.7	30.6	6.6
2008	709.8	43.4	7.3
2009	999.9	39.1	6.8
2010	1,193.9	47.1	4.2
2011	532.7	18.7	8.1
2012	297.2	7.3	7.4
2013	226.3	16.1	6.8
2014	387.6	23.2	5.0
2015	111.4	23.0	4.6
2016	138.8	15.9	3.6
2017	113.9	29.7	2.7
2018	50.0	15.8	1.0
2019	85.3	13.2	1.2
2020	244.2	10.7	1.3

Table 23. Indices used in the ASAP model for the DMV region.

Index Name	Index Metric	Design	Time of Year	Years	Ages
MRIP CPUE	Total catch per angler-trip	Stratified Random	Mar-Dec	1982-2020	1+

Table 24. Model structure and life history information used in the stock assessment.

	Value(s)
Years in Model	1982-2020
Age Plus Group	12+
Fleets	1 (Rec and Commercial)
Recreational Release Mortality Rate	2.5%
Fraction of year before SSB calculation	0.42
Number of selectivity blocks	4
selectivity periods	1982-1996, 1997- 2006, 2007-2011 and 20013-2020
Selectivity type	Single logistic

	Age Group											
	1	2	3	4	5	6	7	8	9	10	11	12+
Proportion mature-at-age	0	0	0.8	1	1	1	1	1	1	1	1	1
Natural mortality	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

Table 25. Spawning stock biomass in metric tons, recruitment (millions of age-1 fish), annual Fishing Mortality (*F*), and 3-year average *F* estimates for the DMV region.

Year	Spawning stock biomass (mt)	Recruitment (millions of age-1 fish)	Annual *F*	3-year Average *F*
1990	5,473	2.05	0.21	
1991	5,806	2.26	0.31	
1992	6,049	1.83	0.18	0.23
1993	6,251	1.36	0.34	0.28
1994	6,118	0.96	0.23	0.25
1995	5,566	0.86	0.45	0.34
1996	4,506	0.93	0.42	0.37
1997	3,837	1.01	0.31	0.39
1998	3,539	1.46	0.30	0.34
1999	3,347	1.23	0.32	0.31
2000	3,507	1.17	0.22	0.28
2001	3,866	1.20	0.12	0.22
2002	4,098	1.08	0.26	0.20
2003	4,204	0.96	0.17	0.18
2004	4,108	1.14	0.37	0.27
2005	3,900	1.29	0.18	0.24
2006	3,894	1.10	0.29	0.28
2007	3,854	1.06	0.25	0.24
2008	3,706	1.02	0.32	0.29
2009	3,168	0.91	0.60	0.39
2010	2,344	1.19	0.83	0.58
2011	1,839	0.71	0.65	0.70
2012	1,802	0.64	0.61	0.70
2013	1,880	0.52	0.20	0.49
2014	2,008	0.83	0.27	0.36
2015	2,081	0.89	0.09	0.19
2016	2,361	1.37	0.12	0.16
2017	2,680	1.05	0.09	0.10
2018	3,297	1.26	0.03	0.08
2019	3,868	0.97	0.05	0.06
2020	4,396	1.08	0.09	0.06

Table 26. SSB and *F* reference points from 2016 and 2021 updates for the DMV region.

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
2016 Update	1,919	1,447	0.16	0.24
2021 Update	4,488	3,355	0.17	0.27

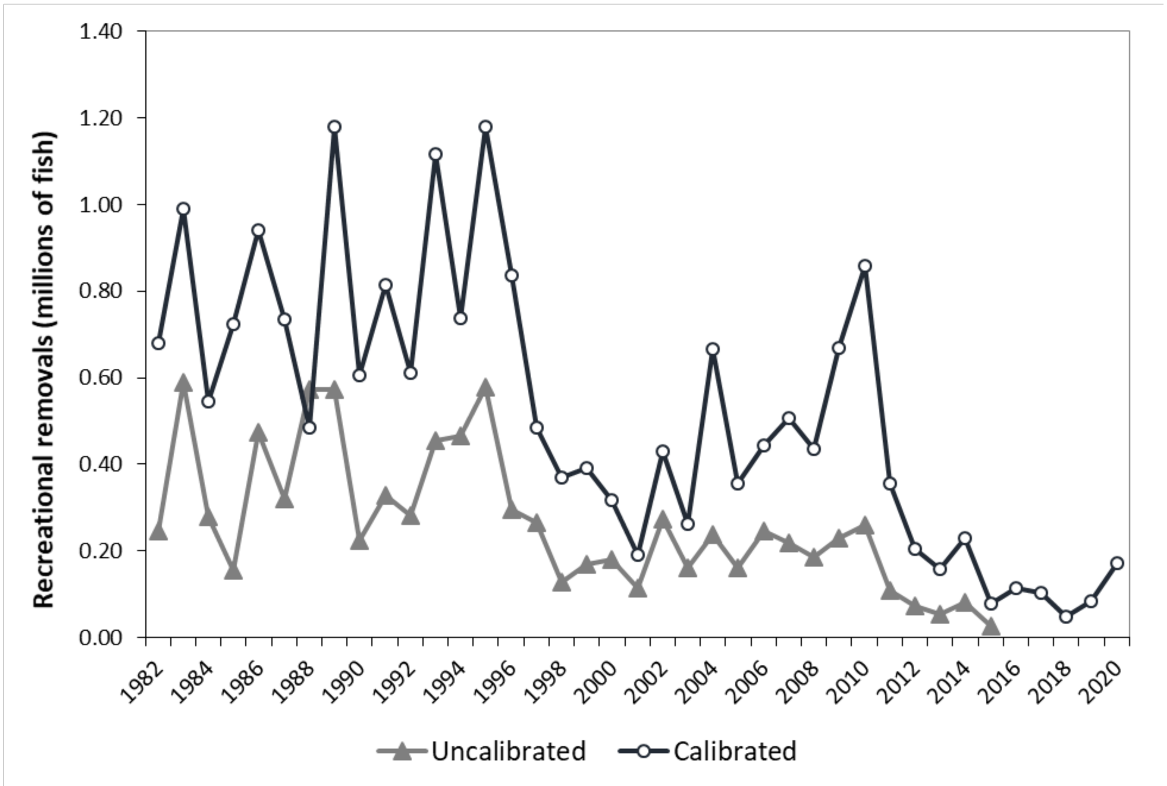
Table 27. Stock status for the DMV region.

	SSB (mt)		*F*	
	Target	Threshold	Target	Threshold
Reference Points	4,488	3,355	0.17	0.27
2020 Estimate	4,396		0.06	
2020 Status	Not Overfished		Not Overfishing	

Table 28. Projection results for the DMV region.

Landings (mt) for 2021-2023	Probability of being at or below *F* Target in 3 years	Probability of being at or above SSB threshold in 3 years
Status quo (2018-2020 average)	100%	100%

Figures



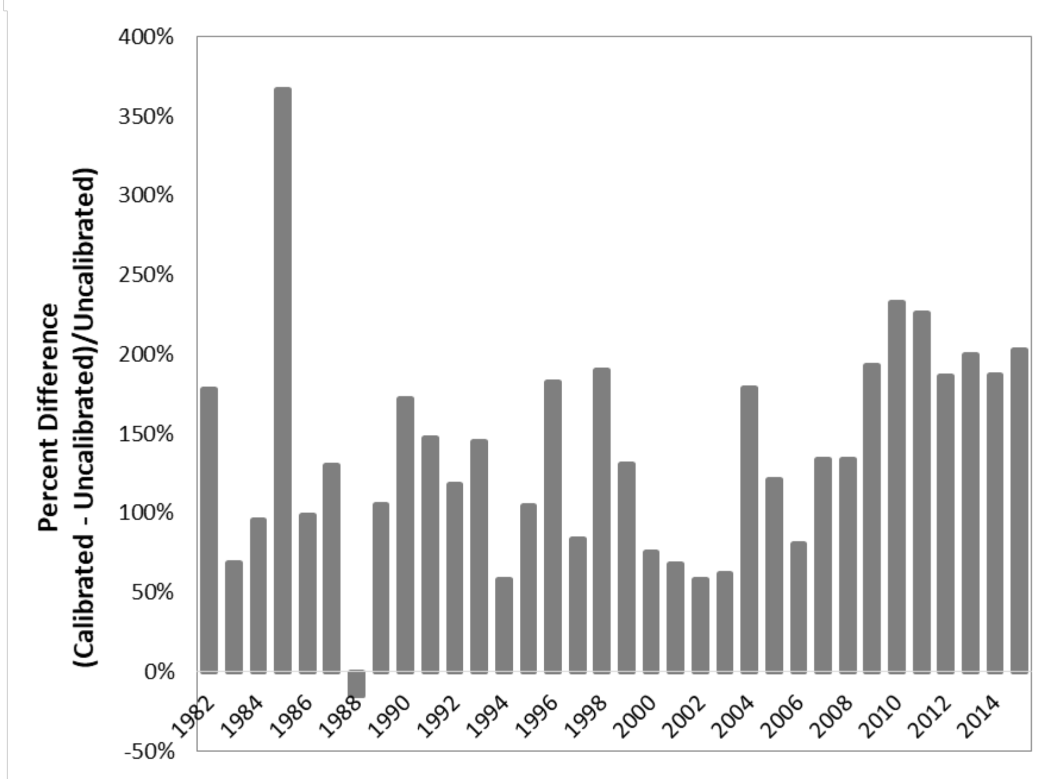


Figure 34. Comparison of calibrated and uncalibrated recreational removals (harvest + release mortalities) in numbers of fish (top) and percent difference (bottom) for the DMV region.

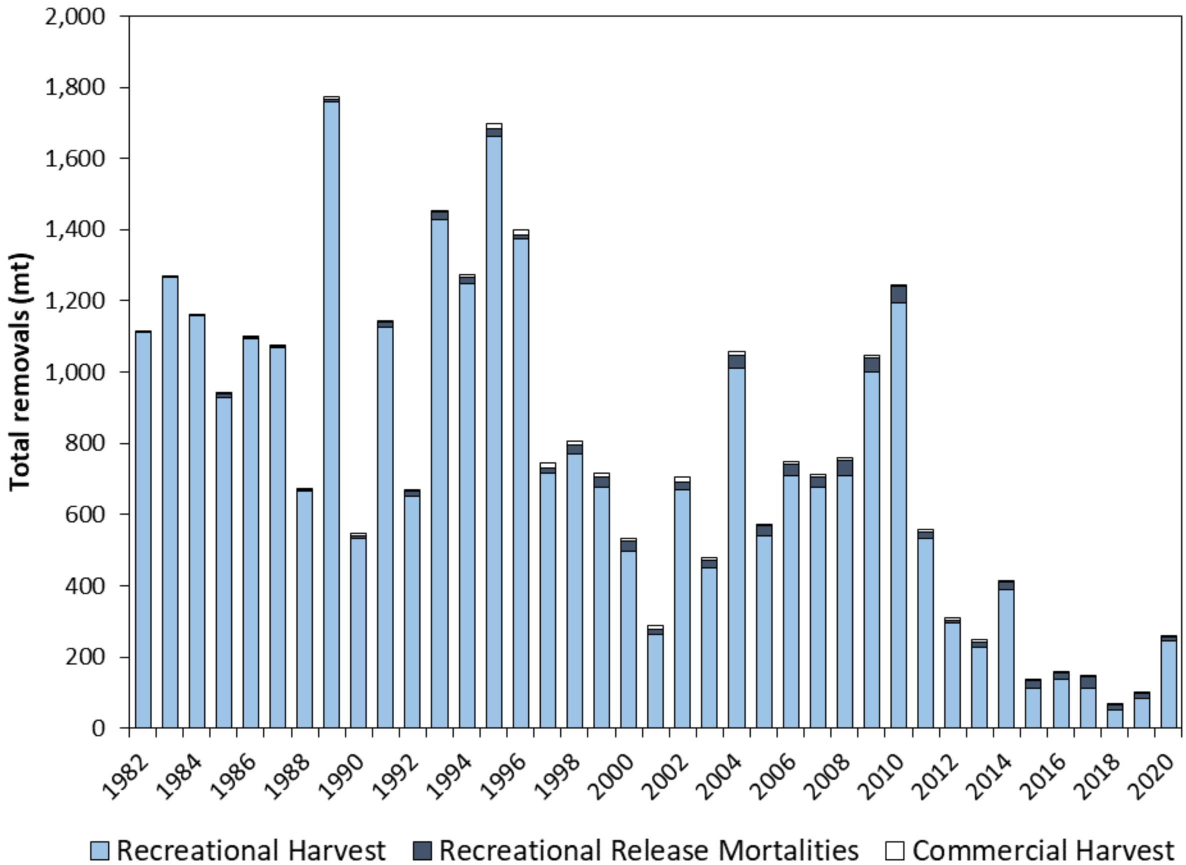


Figure 35. Total removals by sector for the DMV region.

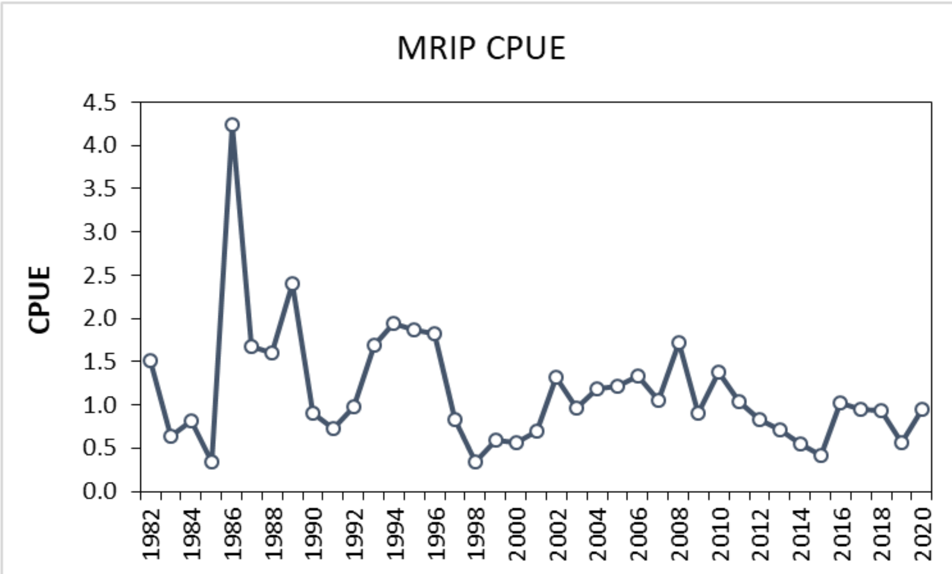


Figure 36. Indices of abundance used for the DMV region.

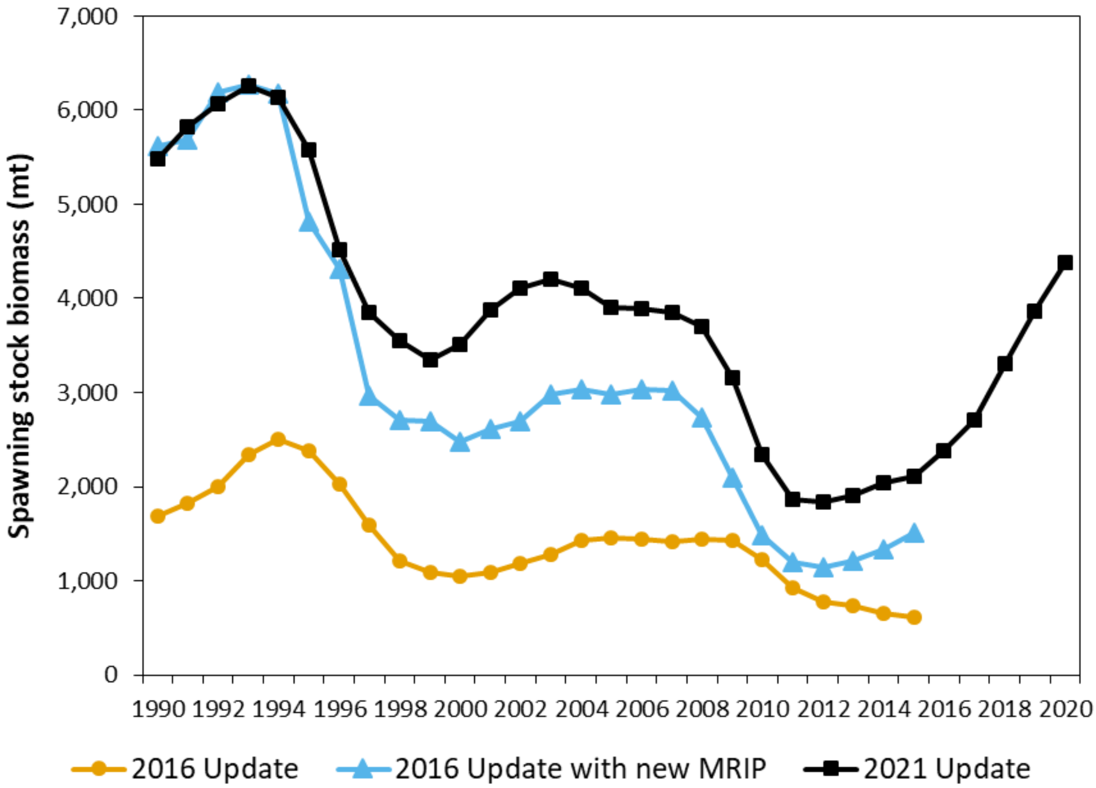


Figure 37. Estimates of spawning stock biomass for the DMV region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

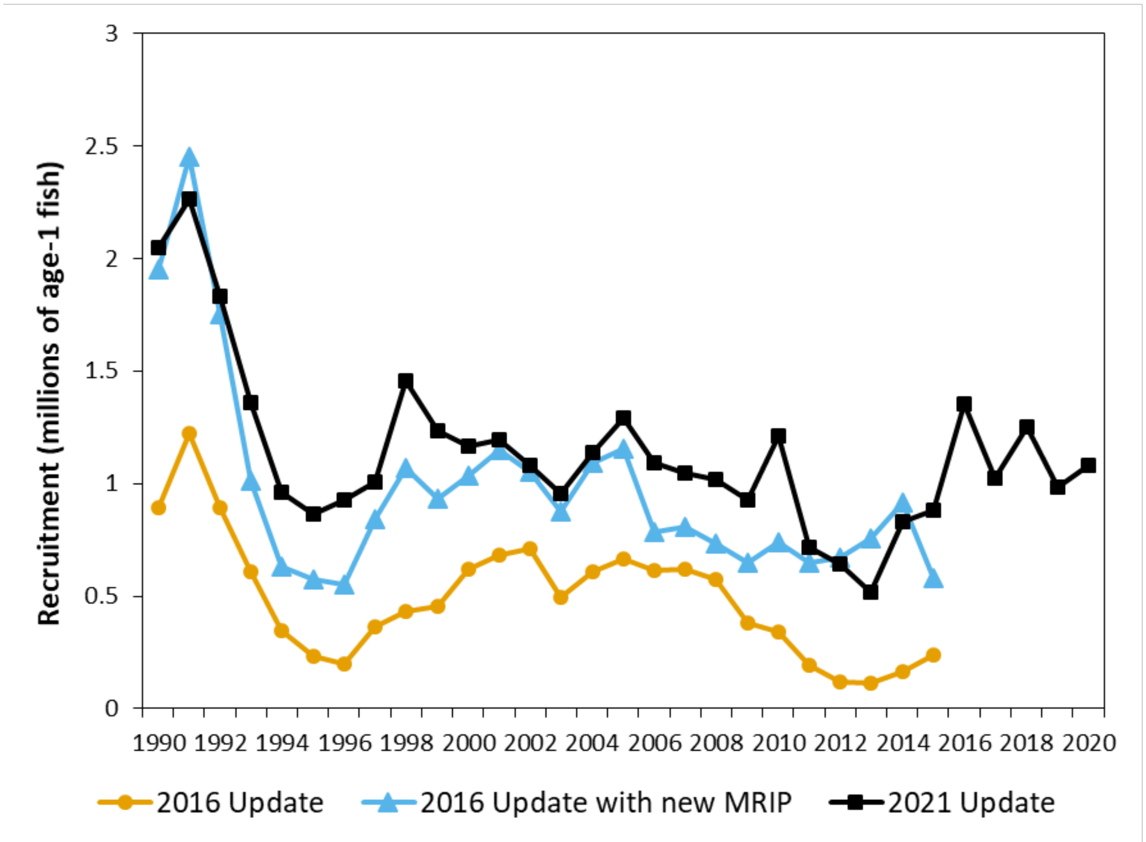


Figure 38. Estimates of recruitment for the DMV region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

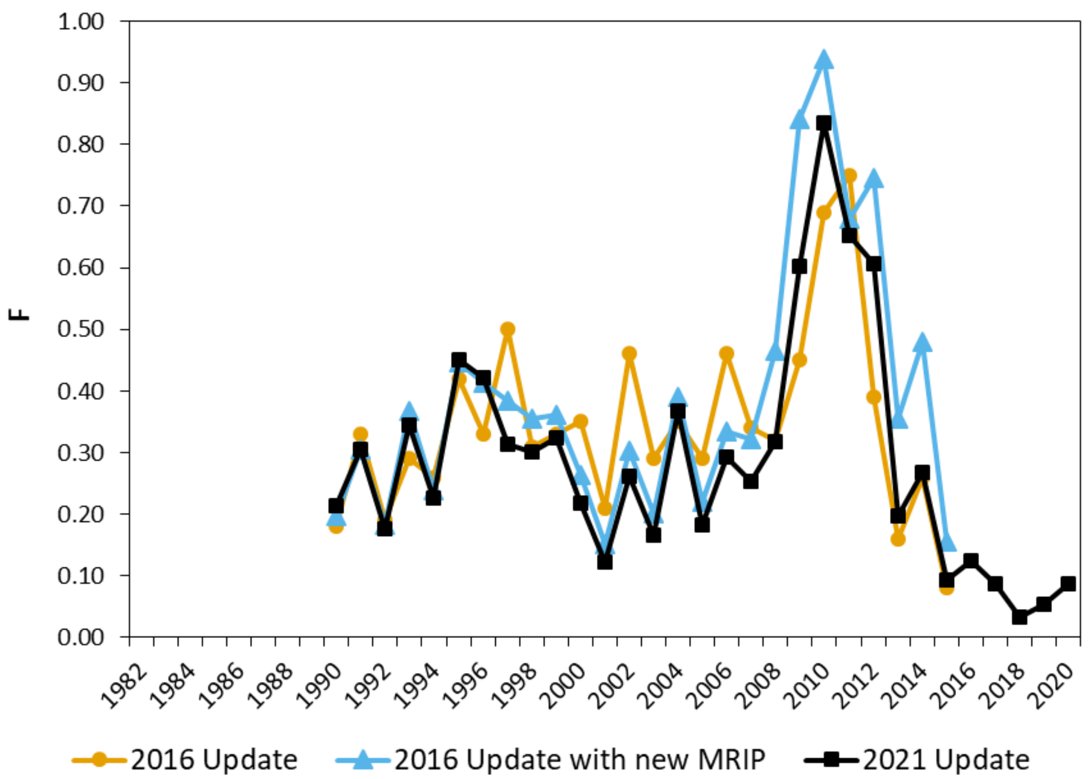


Figure 39. Estimates of the annual full F for the DMV region from the 2016 update, the 2016 model using the calibrated MRIP data, and the 2021 update.

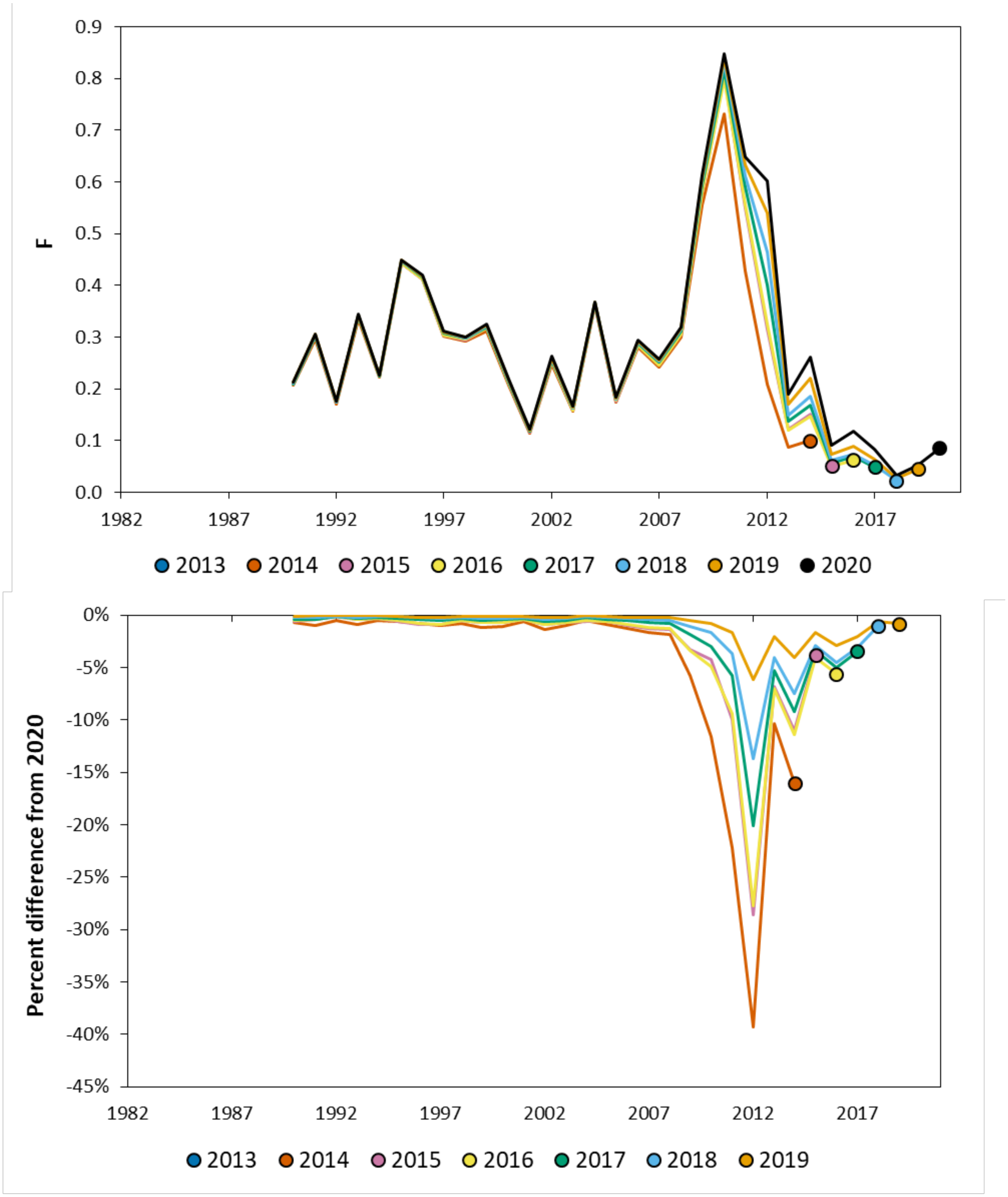


Figure 40. Retrospective analysis for annual *F* in absolute numbers (top) and percent difference (bottom) for the DMV region.

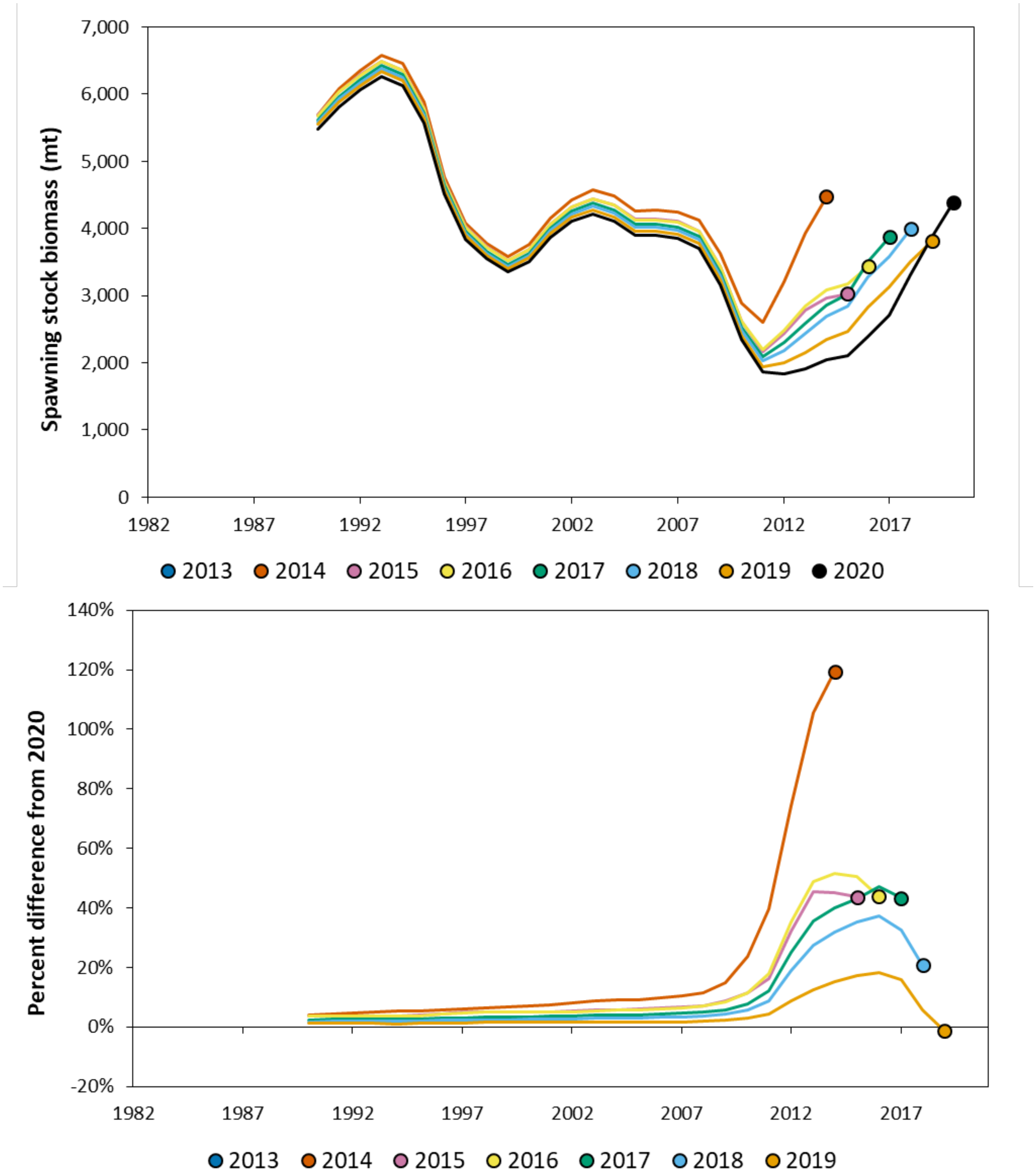


Figure 41. Retrospective analysis for SSB in absolute numbers (top) and percent difference (bottom) for the DMV region.

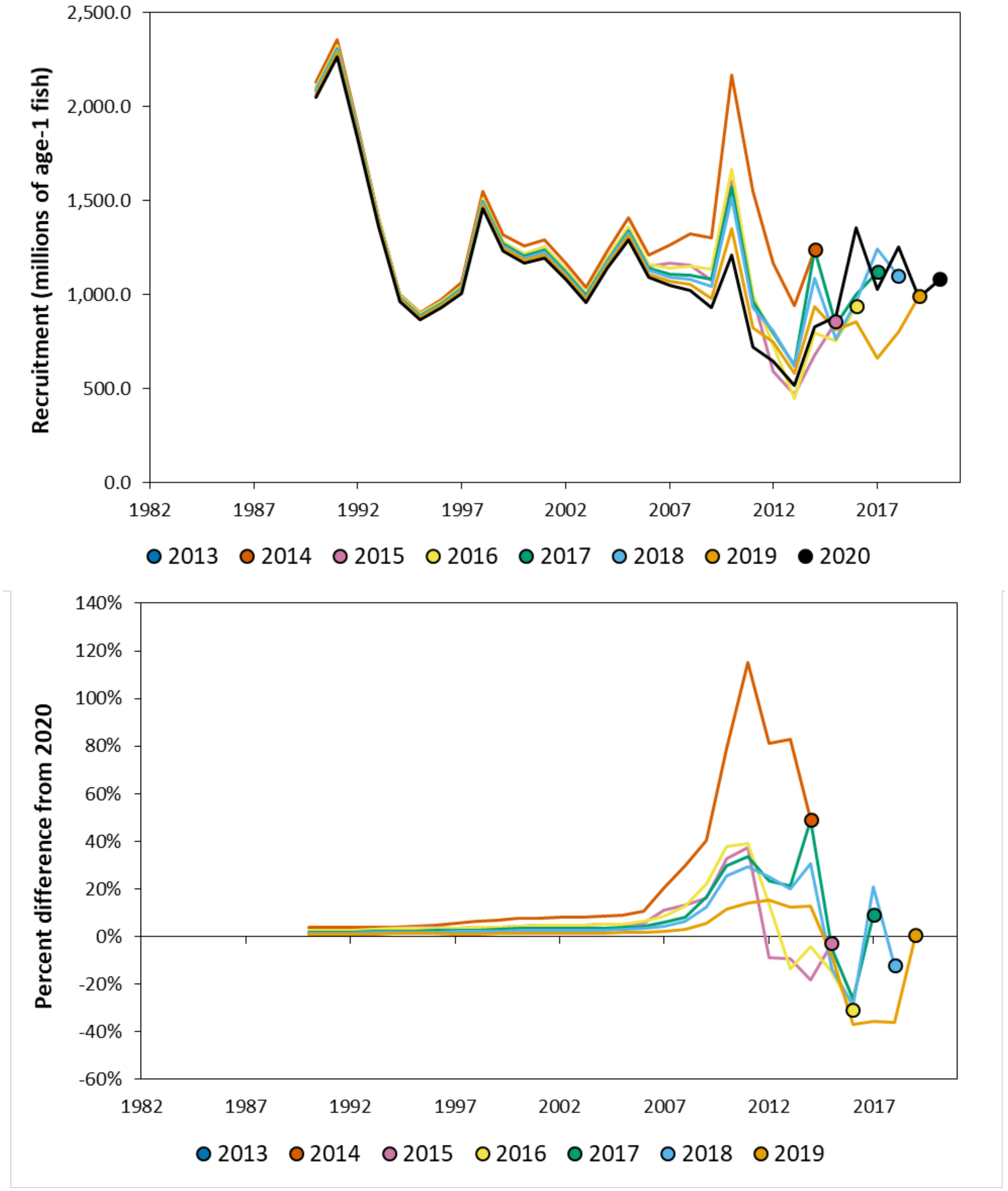


Figure 42. Retrospective analysis for recruitment in absolute numbers (top) and percent difference (bottom) for the DMV region.

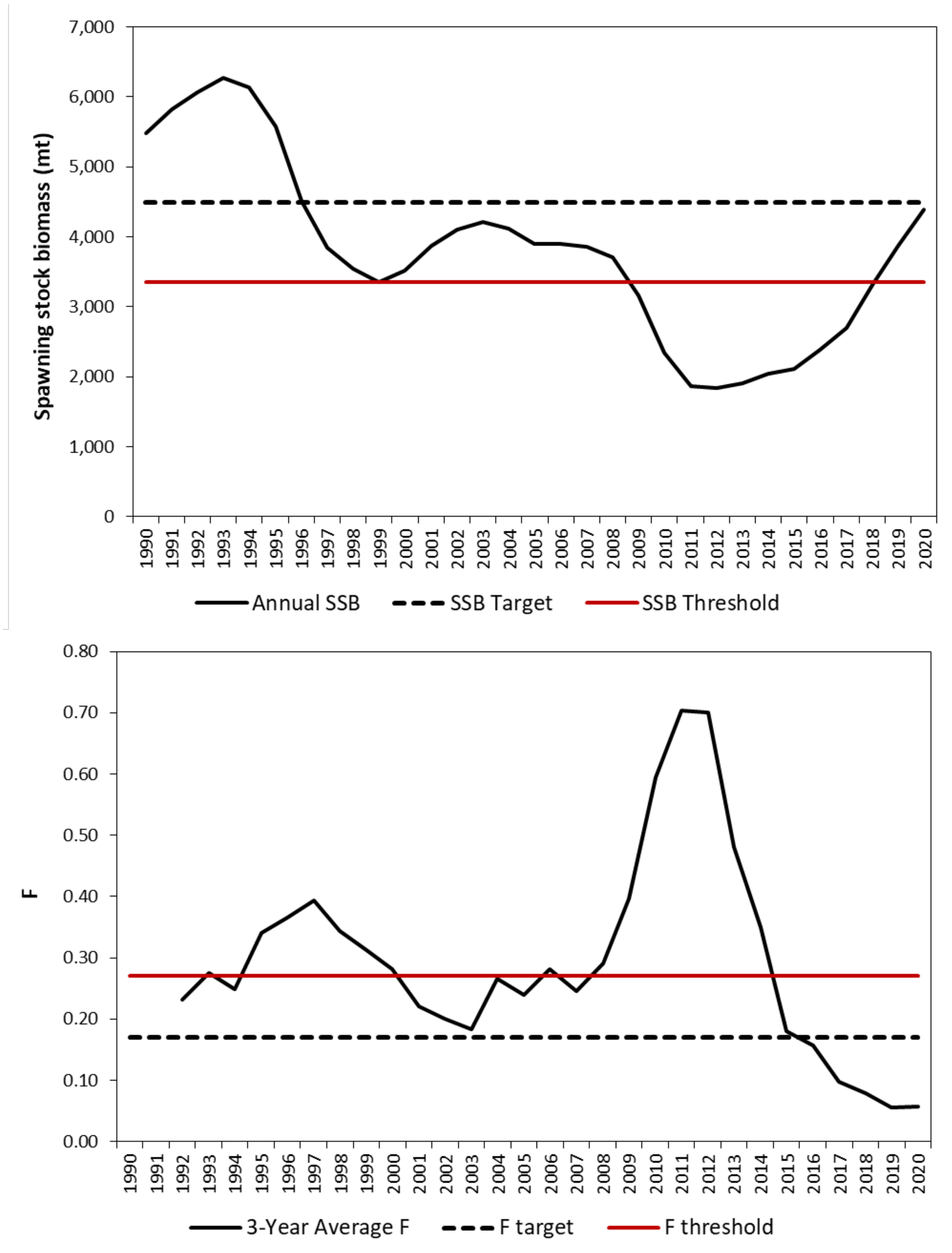


Figure 43. Annual SSB plotted with SSB target and threshold (top) and 3-year average *F* plotted with F target and threshold (bottom) for the DMV region.

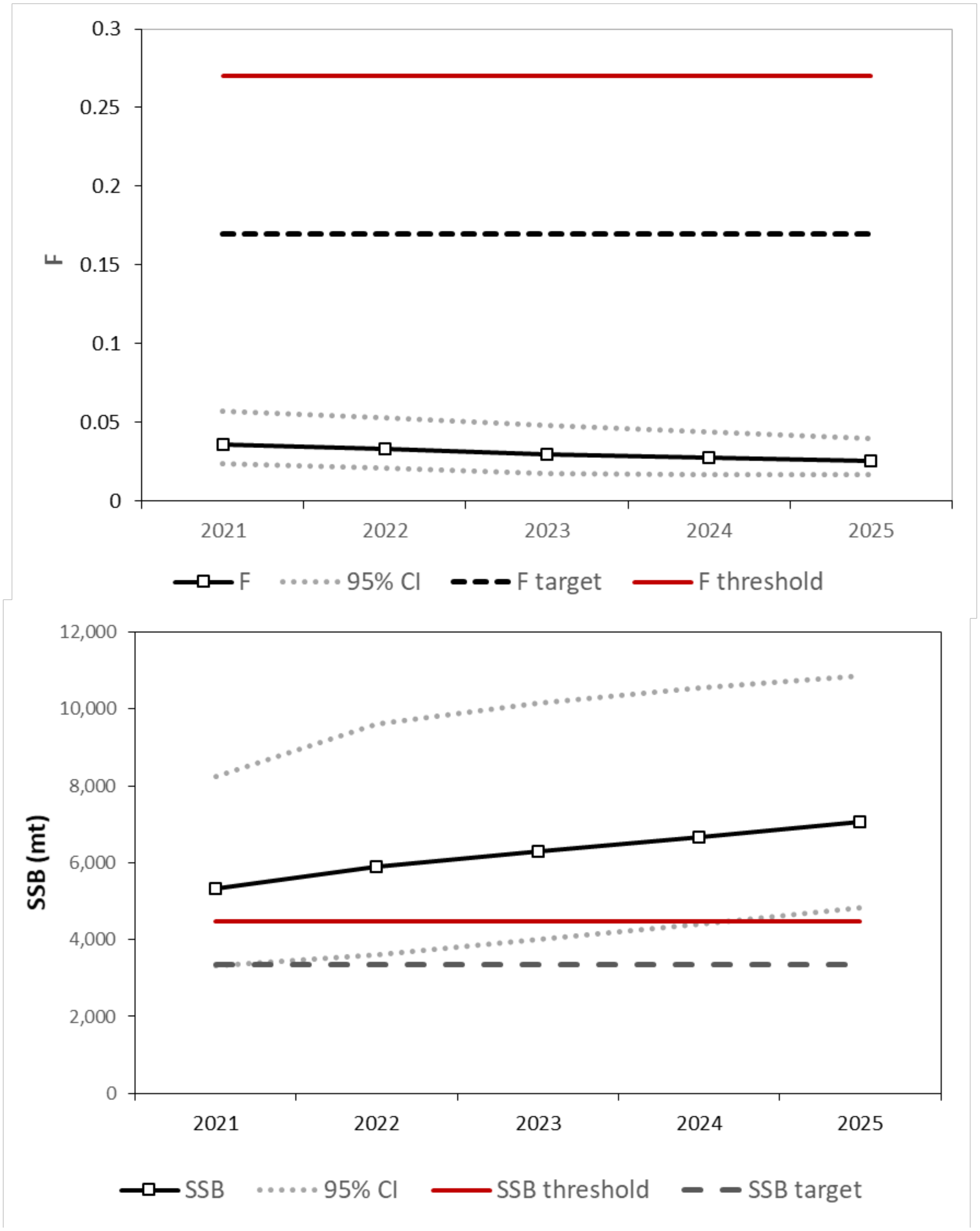


Figure 44. Status quo harvest projections for the DMV region showing the trajectory of annual *F* (top) and SSB (bottom) with their target and threshold reference points. Dotted grey lines indicate the 95% confidence intervals of the estimates.