Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: **Atlantic Striped Bass Plan Development Team**

FROM: **Atlantic Striped Bass Technical Committee**

DATE: **January 6, 2022**

SUBJECT: **Technical Committee Analysis and Considerations for Recreational Size Limits to Protect Strong Year Classes—Chesapeake Bay and Ocean Options**

This memorandum summarizes the Striped Bass Technical Committee's (TC) analysis and discussion for the Draft Amendment 7 year class task based on TC meetings from June through December 2021. Detailed projection methods and figures for the ocean-only change scenarios (developed September 2021) and Chesapeake Bay/ocean change scenarios (developed December 2021) are enclosed at the end of this memo.

Background

The public and the Board expressed concern that the relatively strong 2015 year class will soon enter the current slot limit for the recreational ocean fishery (28" to <35"). Board members noted that protecting the 2015 year class is important for rebuilding the stock overall given the multiple prior years of poor recruitment. If the current recreational ocean slot is maintained, this strong year class will be subject to release mortality as it is approaching the slot, subject to harvest once of size and within the slot, and again subject to release mortality once those remaining fish have reached a size outside the current slot.

In May 2021, the Striped Bass TC was tasked by the Board and Plan Development Team (PDT) with evaluating which strong year classes warrant protection, if they can still be protected if Amendment 7 is implemented in 2023, and what recreational ocean measures may offer the most protection for these strong year classes.

In October 2021, the Board expanded the year class task for Draft Amendment 7 to include recreational slot limit options for the Chesapeake Bay to protect strong year classes.

Strong Year Classes

To address the question of other year classes to consider protecting in addition to the 2015 year class, the TC noted that both the 2017 and 2018 year classes were above average in multiple JAIs and recommended including those year classes in this analysis. Comparing the impacts of size/slot limits on different year classes will help inform a discussion of tradeoffs between protecting different age classes in the population.

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Ocean Size/Slot Limits

The status quo coastwide recreational slot limit of 28” to <35” adopted under Addendum VI was estimated to achieve the 18% reduction in total recreational removals needed to reduce F to the target in 2020. Three additional recreational options for the ocean fishery (35” minimum size, 30 to <38” slot, 32 to <40” slot) were included in Draft Addendum VI, all of which were estimated to achieve at least an 18% reduction in total recreational removals. As these three alternate options are all at least equivalent to the current recreational slot in regards to estimated % change in total removals from 2017, the TC agreed that these alternate options would be good candidate options to evaluate for protecting the strong 2015, 2017, and 2018-year classes.

The TC recommended evaluating one size/slot limit option in each of the following categories: (1) status quo slot limit; (2) minimum size limit; (3) shift to larger slot than the status quo; and (4) shift to a smaller slot than the status quo. Based on that recommendation and the PDT’s interest in exploring a narrower slot limit instead of shifting to a smaller slot limit, the PDT provided guidance to the TC on which scenarios to include in the TC’s projection analysis: 28” to <35” status quo slot; 35” minimum size; 32” to <40” larger slot; 28” to <32” narrower slot (Table 1).

Chesapeake Bay Size/Slot Limits

The status quo 18” minimum size and 1 fish bag limit for the Chesapeake Bay recreational fishery was adopted under Addendum VI to achieve at least an 18% reduction in total recreational removals from 2017 needed to reduce F to the target in 2020. As of 2021, Maryland, PRFC, and Virginia are operating under approved CE programs that include alternative size and bag limits, shortened or eliminated trophy seasons, and seasonal closures.

The PDT identified two Chesapeake Bay slot options to consider: 18” to <23” slot and 18” to <28” slot. The 18 to <23” slot option was included as an alternative in Draft Addendum VI and was also estimated to achieve at least an 18% reduction in removals. The PDT was also interested in a larger slot option and selected 18” to <28” to consider.

Length-At-Age

In order to address questions about specific year classes, estimates of length-at-age are needed. The TC discussed the challenges of addressing questions about specific year classes, including that there is no model-based accepted growth curve for striped bass and the high variability of size-at-age depending on location along the coast.

The TC considered two datasets to develop growth curves for this analysis: the USFWS tagging database and the state age data (fishery dependent and independent sources) compiled for the benchmark stock assessment (terminal year 2017). The two databases provided similar lengths-at-age, means, standard deviations, and growth curves with some differences for the youngest (age 1) and oldest (age 20+ ages). The TC also evaluated differences in growth curves depending on the timeframe of data used. Growth curves were similar for each decade, but 1980s fish attained the largest length at older ages, and 2000s fish attained the smallest. The

2010s timeframe provided data from a greater number of states than the 1980s or 1990s timeframe. The 2000s timeframe showed truncated data (fewer older fish), reflecting recruitment failures of the 1970s and 1980s. After discussion, the TC recommended using the state age data for the most recent five years available as compiled for the stock assessment and weighting each state's data by the total recreational catch from that state to develop length-at-age estimates (Table 1).

Table 1. Estimated mean striped bass size-at-age based on the 2012-2016 state age data (weighted by state recreational catch) compiled for the 2018 benchmark stock assessment. Note: Size-at-age is highly variable along the coast and there is overlap among age classes.

Age	Estimated Mean Total Length (in)	
0	3.8	
1	6.4	
2	12.7	
3	17.0	
4	20.9	
5	**24.1**	**2018 year class in 2023**
6	**26.4**	**2017 year class in 2023**
7	28.7	
8	**31.6**	**2015 year class in 2023**
9	33.8	
10	35.5	
11	37.2	
12	39.1	
13	41.0	
14	42.2	
15+	44.0	

The length-at-age estimates were incorporated into an R shiny app that was previously developed as a tool to examine various size limit combinations. For any selected size or slot limit, the app plots the predicted length frequency of year classes within a size limit. The app was also updated to provide a selectivity value for each size/slot limit and to list the percent of fish at each age that would be greater than, less than, or within a slot limit. The percent of fish for each age class that is within a size/slot limit would be the percent of fish that are subject to harvest. The percent of fish for each age class that is greater than and/or less than the size/slot limit would be protected from harvest. The TC noted that although fish outside the slot/size limit are protected from harvest, they are still subject to release mortality. The TC also noted that because most striped bass that are caught are released alive in the recreational fishery, the harvest component is relatively small, so changing the size limits to protect one year class from harvest may not have a big impact on stock health.

All alternative scenarios considered for this analysis would provide greater protection from harvest for the 2015 year class in the year 2023 (when the 2015s are age-8) relative to the status quo (Table 2 and Table 3). However, the level of protection for each year class will change in future years as those fish age. For example, the protection provided by the status quo slot limit will increase as the 2015 year class gets older, while the protection provided by the 35" minimum will decrease.

Table 2. Percent of fish protected from harvest (outside the size/slot limit) for each age for ocean size/slot options. The ages of the 2015, 2017, and 2018 year classes in 2023 are in bold.

					2018 YC in 2023	**2017 YC in 2023**		**2015 YC in 2023**							
Size/Slot	A1	A2	A3	A4	**A5**	**A6**	A7	**A8**	A9	A10	A11	A12	A13	A14	A15+
28 to <35	100	100	100	98.9	**90.0**	**68.8**	46.6	**33.4**	40.1	56.9	75.1	92.0	98.4	99.7	100
35 min	100	100	100	100	**100**	**99.4**	95.5	**82.9**	64.0	44.2	25.1	8.0	1.6	0.3	0.0
32 to <40	100	100	100	100	**99.5**	**95.1**	81.3	**55.8**	32.7	22.9	24.2	38.1	64.1	80.3	93.9
28 to <32	100	100	100	98.9	**90.5**	**73.2**	61.0	**61.4**	74.6	86.7	94.8	99.3	99.9	100	100

Table 3. Percent of fish protected from harvest (outside the size/slot limit) for each age for Chesapeake Bay size/slot options. The ages of the 2015, 2017, and 2018 year classes in 2023 are in bold.

					2018 YC in 2023	**2017 YC in 2023**		**2015 YC in 2023**							
Size/Slot	A1	A2	A3	A4	**A5**	**A6**	A7	**A8**	A9	A10	A11	A12	A13	A14	A15+
18 min	100	97.9	63.9	17.2	**2.4**	**0.7**	0.2	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18 to <23	100	97.9	65.8	42.5	**65.9**	**84.8**	94.1	**99.1**	99.9	100	100	100	100	100	100
18 to <28	100	97.9	63.9	18.3	**12.4**	**32.4**	58.1	**83.7**	95.9	98.9	99.8	100	100	100	100

Projection Scenarios

The TC discussed the importance of developing stock projections to evaluate the potential impact on SSB and stock productivity of changing the size/slot limit, as compared to the status quo. While changing the size/slot limit may protect a year class from harvest in the near-term, the potential effects on long-term stock productivity need to be considered.

Projections were developed to compare the impacts of alternative size/slot limits on SSB over the next 12 years (timeframe allowing all three year classes of interest to reach age-14) by changing the selectivity for each size/slot limit. The detailed projection results and methods are enclosed at the end of this memorandum.

In September 2021, projections were developed for the alternative ocean slot/size options assuming the Chesapeake Bay recreational measures would remain status quo (Table 4). In

December 2021, projections were developed for combinations of alternative ocean and Chesapeake Bay slot limits to compare to the status quo scenario (Table 5). Each scenario uses a combined selectivity comprised of ocean and Bay length-based selectivity vectors for the size/slot limits of interest. This second set of projections focused on scenarios in which both the Chesapeake Bay and ocean size/slot limits changed from the status quo. As recommended by TC members, the projection scenarios highlight combinations of Chesapeake Bay and ocean size/slot limits that would protect the widest range of sizes from harvest in both the Chesapeake Bay and the ocean. For example, the combination of an 18" to <28" slot in the Chesapeake Bay with a 35" minimum size in the ocean would protect fish between 28" and <35" from harvest across both fisheries.

Table 4. Ocean-only change projection scenarios and selectivity vectors developed in September 2021.

		Period			
		Add VI 2020-2022		Amendment 7 2023-forward	
Scenarios	**Description**	**Ches Bay**	**Ocean**	**Ches Bay**	**Ocean**
Status Quo 1	Ocean status quo slot (Ches Bay status quo)	selectivity from 2018 assessment	28-<35	selectivity from 2018 assessment	28-<35
2	Ocean min size (Ches Bay status quo)	selectivity from 2018 assessment	28-<35	selectivity from 2018 assessment	35 min
3	Ocean large slot (Ches Bay status quo)	selectivity from 2018 assessment	28-<35	selectivity from 2018 assessment	32-<40
4	Ocean narrower slot (Ches Bay status quo)	selectivity from 2018 assessment	28-<35	selectivity from 2018 assessment	28-<32

Table 5. Chesapeake Bay and ocean change projection scenarios and selectivity vectors developed in December 2021.

		Period			
		Add VI 2020-2022		Amendment 7 2023-forward	
Scenarios	**Description**	**Ches Bay**	**Ocean**	**Ches Bay**	**Ocean**
Status Quo 1	Ches Bay status quo with ocean status quo slot	selectivity from 2018 assessment	28-<35	selectivity from 2018 assessment	28-<35
2	Ches Bay small slot with ocean large slot	selectivity from 2018 assessment	28-<35	18-<23	32-<40
3	Ches Bay small slot with ocean min size	selectivity from 2018 assessment	28-<35	18-<23	35 min
4	Ches Bay large slot with ocean large slot	selectivity from 2018 assessment	28-<35	18-<28	32-<40

5	Ches Bay large slot with ocean min size	selectivity from 2018 assessment	28-<35	18-<28	35 min

Projection Discussion

The enclosed projection results specify the assumptions used to develop these projections, including an assumption of fishing at constant F target for 2018 forward and assuming constant effort for all scenarios. Changes in effort associated with different size/slot limits cannot be predicted. If effort were to increase relative to the status quo in response to a size/slot limit change, SSB levels may be less than projected. If effort were to decrease relative to the status quo in response to a size/slot limit change, SSB levels may be higher than projected.

For 2020 forward, the projections use new selectivity values generated from the length-at-age analysis described above. These length-based selectivity values will be reviewed as part of the next stock assessment update, which will generate updated selectivity values based on new data years added to the stock assessment.

It is important to note that these projections assume both the commercial and recreational sectors adopt the alternative slot limits, due to the difficulty of developing sector-specific selectivity vectors. If only the recreational sector implements the new slot limits, the change in SSB would likely be less than the projection results indicate.

The projection analysis indicates the following key findings for all scenarios:

- The stock recovery timeline (i.e., the year SSB exceeds the threshold and the year SSB exceeds the target) is the same for all scenarios, including the status quo scenarios.
- The projected overall change in total SSB (all year classes) relative to the status quo is positive for most scenarios (Table 6); however, the percent change in total SSB is not statistically significant since it falls within the confidence interval of the SSB estimates from the status quo projections.
- Under all scenarios, the 2015 year class will have a higher contribution to stock productivity than the 2017 and 2018 year classes.
- The projected change in year-class-specific SSB (total SSB for each year class over time) relative to the status quo is mostly positive with some negative changes for the 2015 year class SSB for some scenarios (Table 6).
- These results indicate that changing the selectivity does not have a significant impact on rebuilding the stock if the F rate remains constant. If the goal is to expedite stock rebuilding, controlling the overall F rate is more important than only changing the selectivity.

The TC notes that for all scenarios, there is uncertainty around how angler behavior and effort will change in response to change in size/slot limit. Additionally, slot limits are associated with higher discards, particularly for narrower slot limits. A large minimum size limit could also result in higher discards. While discard mortality is included in the projections through the selectivity patterns, the projections assume that total effort is the same across all scenarios.

The TC emphasized that while these projections can inform a comparison between the relative impacts of different size/slot options, these projections are not intended to inform discussion about the recovery timeline for the stock. For example, the projection analysis indicates that all the scenarios evaluated in the projections, including the status quo, will result in the same stock recovery timeline; however, the estimated year in which SSB exceeds the target or threshold may change after additional data from recent years are incorporated into the assessment model during the next stock assessment update. If the Board would like to see projections to inform the stock rebuilding plan, the TC can be tasked to develop those projections as part of the next assessment update.

Note on Implementation Timeline

The TC notes there will be a stock assessment update completed in October 2022, before Amendment 7 is potentially implemented in 2023. If the Board is required to respond to the assessment update based on the stock status determination, that response may or may not align with the scenarios considered in this analysis. Further, there may be a benchmark assessment complete within a few years of Amendment 7 implementation, so it will be difficult to predict or plan for management changes for years immediately following Amendment 7 implementation.

Table 6. Percent change in median total age-specific SSB relative to the status quo and maximum percent change in total SSB (all year classes) relative to the status quo for projection scenarios developed for changing both the Chesapeake Bay and ocean size limits (green) and changing only the ocean size limit (blue) assuming implementation by both the commercial and recreational sectors. SQ=Status Quo.

	Chesapeake Bay and Ocean Size Limit Change Scenarios				**Ocean Only Size Limit Change Scenarios**		
Ches Bay	**18-<23**	**18-<23**	**18-<28**	**18-<28**	**SQ**	**SQ**	**SQ**
Ocean	**32-<40**	**35 min**	**32-<40**	**35 min**	**32-<40**	**35 min**	**28-<32**
2015 YC SSB	-2%	+11%	-2%	+11%	-4%	+6%	+4%
2017 YC SSB	+6%	+24%	+4%	+22%	+2%	+17%	+2%
2018 YC SSB	+14%	+35%	+9%	+29%	+8%	+22%	-0.5%
Total SSB	**+5%**	**+14%**	**+1%**	**+8%**	**+1%**	**+5%**	**-3%**

Note: If only the recreational sector implements the new slot limits, the change in SSB would likely be less than the projection results in this table.

<u>Enclosed: CHESAPEAKE BAY/OCEAN CHANGE Projections for Alternate Size Regulation Scenarios Using Weighted Selectivity Vectors (December 2021)</u>

I used the standard projection model used in the assessment. I examined constant F scenarios with constant F = F target (0.197) starting in 2018. The starting year of the model was parameterized with the 2017 bias-corrected estimates of ages 1-15+ abundances and F. Error in these estimates was included, so that values for each run were re-sampled from normal distributions parameterized with estimates and corresponding standard errors from the SCA model.

Annual recruitment for years 2018-2021 were forecasted from the Maryland and New Jersey YOY indices for years 2017-2020 (lagged one year ahead) by using a multiple regression equation fitted to 1982-2017 SCAA age-1 numbers and the Maryland and New Jersey YOY indices (lagged ahead one year) for the same years. Variation was added to the forecasted values by resampling the vector of residuals from the model fit.

Annual recruitment for years > 2021 was generated from spawning stock biomass by using the "Hockey Stick" approach used in the 2018 benchmark. A Beverton-Holt SR equation is used to generate age-1 numbers if the previous year's female spawning stock biomass is less than the median SSB of 1982-2017 SCA estimates; otherwise, the median of recruitment estimates for 1982-2017 is used. Variation is added to a recruitment estimate by resampling the vector of residuals from the Beverton-Holt model fit.

Projections started at 2017 and ended at year 2032. The latter year was selected to allow the 2015, 2017, and 2018 year classes to reach age 14 (see below). Five thousand runs were made for scenario investigated.

<u>Scenarios</u>

Five scenarios of time-varying size regulations were examined:

		Period			
		2020-2022		2023-forward	
Scenarios	Description	Ches Bay	Ocean	Ches Bay	Ocean
1	Ches Bay status quo with ocean status quo slot	Bay selectivity from 2018 assessment	28-<35	selectivity from 2018 assessment	28-<35
2	Ches Bay small slot with ocean large slot	Bay selectivity from 2018 assessment	28-<35	18-<23	32-<40
3	Ches Bay small slot with ocean min size	Bay selectivity from 2018 assessment	28-<35	18-<23	35 min
4	Ches Bay large slot with ocean large slot	Bay selectivity from 2018 assessment	28-<35	18-<28	32-<40
5	Ches Bay large slot with ocean min size	Bay selectivity from 2018 assessment	28-<35	18-<28	35 min

The size limit scenarios were investigated by changing age-specific selectivity vectors over time. For year 2017, the selectivity vector from the SCA model was used, and for years 2018-2019, the average of selectivity for years 2015-2017 was used. Selectivity vectors were developed by weighting the selectivities generated using Mike Celestino's app and the Bay-wide selectivity vector from 2018 assessment by relative F (Fbay versus Fcoast) in 2017 (Figure 1).

Year-Class Contribution to Female Spawning Stock Biomass

Given age-1 estimates of abundance for year classes 2015 (SCA model), 2017 (forecast equation) and 2018 (forecast equation), the female spawning stock biomass in absence of fishing was calculated using the same projection equations. Error was added to the age-1 estimates by using the same methods as described above for the annual recruitment values. The median and 95% percentiles of the total SSB for age 1-14 were saved. Only SSB through age 14 were used because age 15 is a plus-group which represents multiple cohorts.

In addition, changes in total SSB under scenarios 2-4 relative to scenario 1 (status quo) were examined.

For each scenario, median and 95% percentiles of age-specific and total SSB for each year class were saved. The medians of SSB from each scenario and under no fishing were used to compute the percentage of maximum SSB resulting from time varying regulations for each year class.

Note*: The projections assume both the commercial and recreational sectors adopt the new slot limits.*

Results

The projections suggest female SSB will exceed the SSB threshold and target on the same timeframe under all scenarios, assuming the F target of 0.197 is maintained throughout all years.

Age-specific and total SSB for year classes 2015, 2017 and 2018 are shown in Figures 2-6 for each scenario. Under all scenarios, year class 2015 SSB is larger than 2017 and 2018, and 2018 SSB is larger than 2017. Compared to scenario 1 (status quo), the size limit regulation change in scenario 2 starting in 2023 decreased SSB age-specific and total SSB for 2015, but increased SSB in the 2017 and 2018 year-classes. Under scenario 3, there was a large increase in SSB for all year-classes. Under scenario 4, SSB of the 2015 year-class decreased slightly but SSB for the 2017 and 2018 year-classes increased. Under scenario 5, large increases in SSB for all year classes occurred. These changes are more apparent when SSB from scenarios 2-5 are compared to the SSB from scenario 1 (Figure 7). Under scenarios 2 and 4, the SSB for the 2015 year-classes declined slightly (1.6-2.1%), but SSB for the 2017 and 2018 year-classes increased 4-6% and 9-14%, respectively. Under scenarios 3 and 5, SSB of the 2015 year-class increased by about 11% and the SSB of the 2017 and 2018 year-classes increased 22-24% and 29-35%, respectively.

The percentage of each year class's SSB under each scenario is compared to its maximum potential under no fishing is shown in Figure 8. For the 2015 and 2018 year-classes, % max SSB was about 40% or greater under all scenarios. For the 2017, % max SSB fluctuated about 30%.

Figure 9 shows the change in total female SSB for all year classes under scenarios 2-5 compared to scenario 1 (status quo) for each year. Under scenario 2, total SSB increased relative to the status quo with a maximum increase of 5% at the terminal projection year of 2032. Total SSB also increased to a maximum of 14% under scenario 3. Under scenario 4, the maximum increase in SSB was 1.4% which occurred in 2025. Under scenario 5, total SSB increased to a maximum of 8.2% at the terminal projection year of 2032.

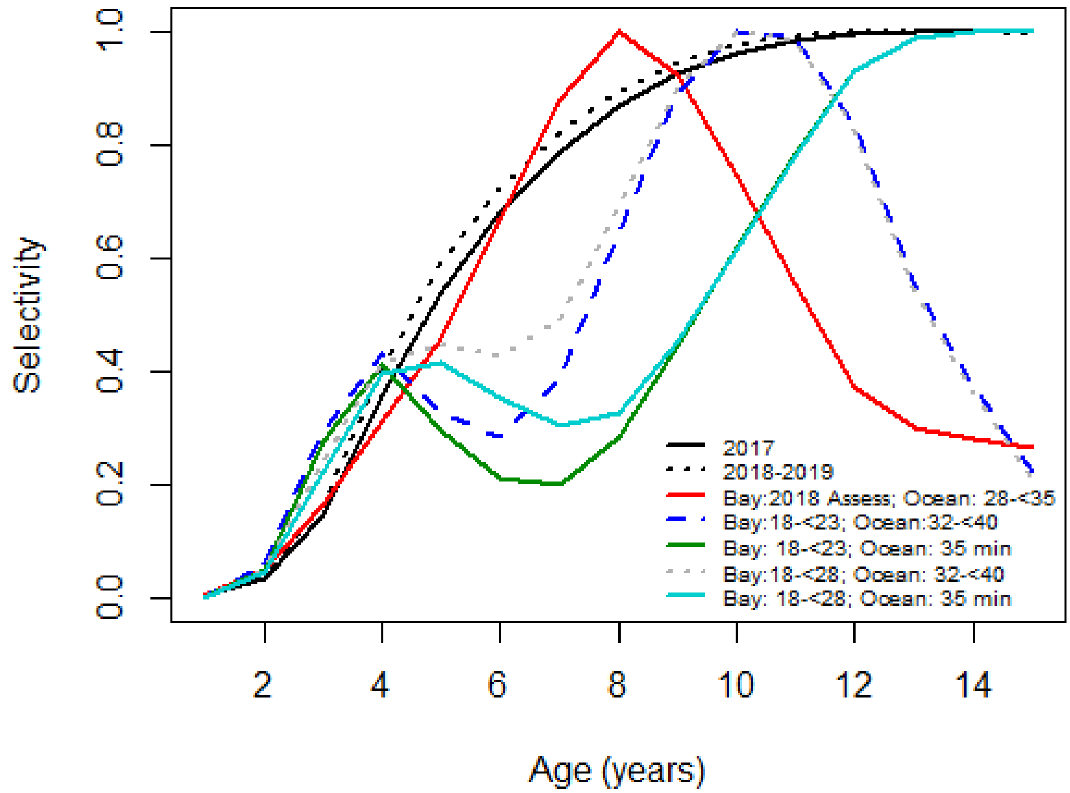


Figure 1. Age-specific selectivity values used in the projections under the five scenarios.

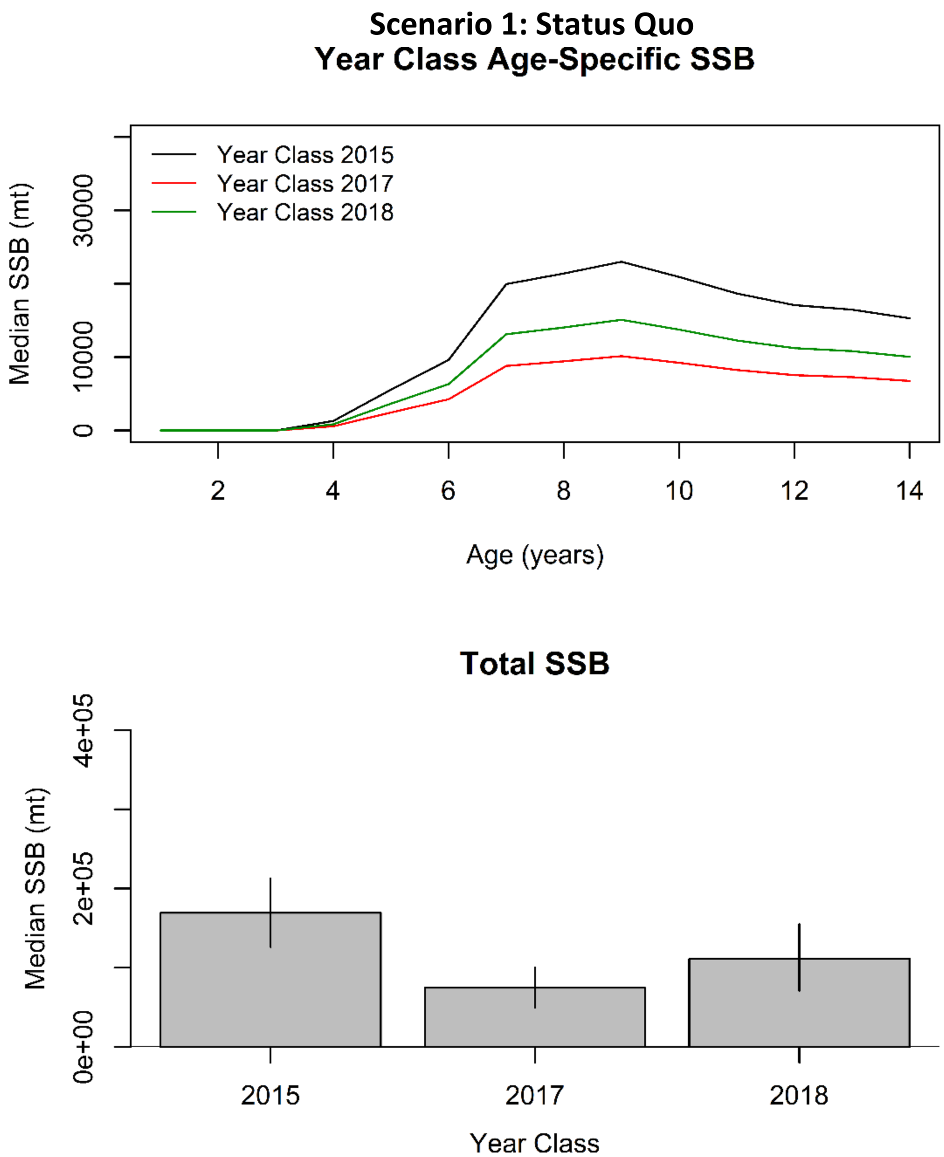


Figure 2. Age-specific (above) and total female spawning stock biomass (below) of the 2015, 2017, and 2018 year classes under scenario 1 (status quo).

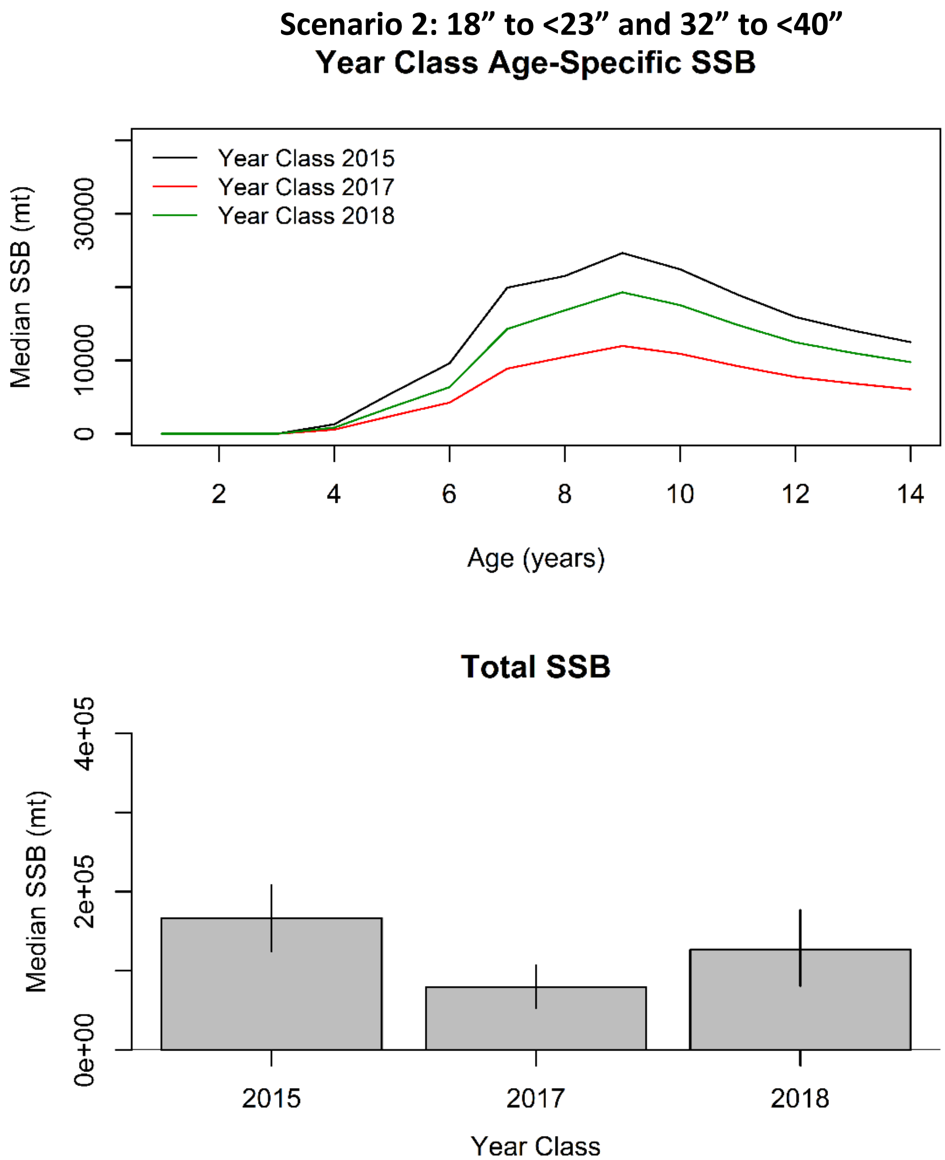
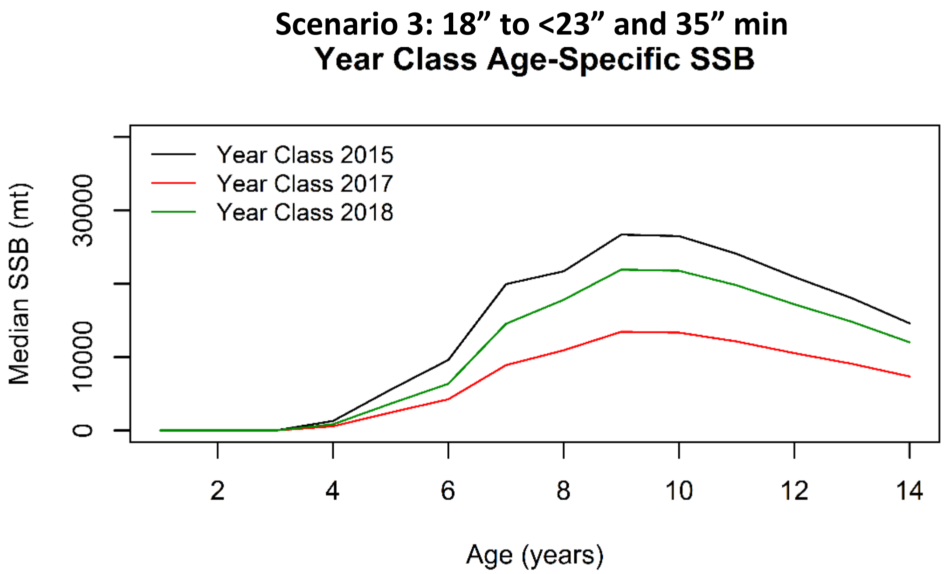


Figure 3. Age-specific (above) and total female spawning stock biomass (below) of the 2015, 2017, and 2018 year classes under scenario 2 (18” to <23” and 32” to <40”).



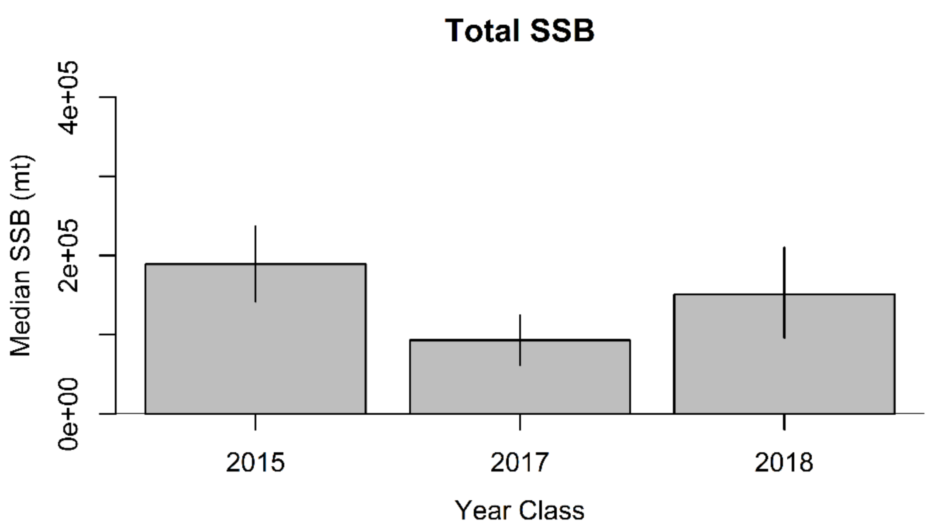


Figure 4. Age-specific (above) and total female spawning stock biomass (below) of the 2015, 2017, and 2018 year classes under scenario 3 (18” to <23” and 35” minimum size).

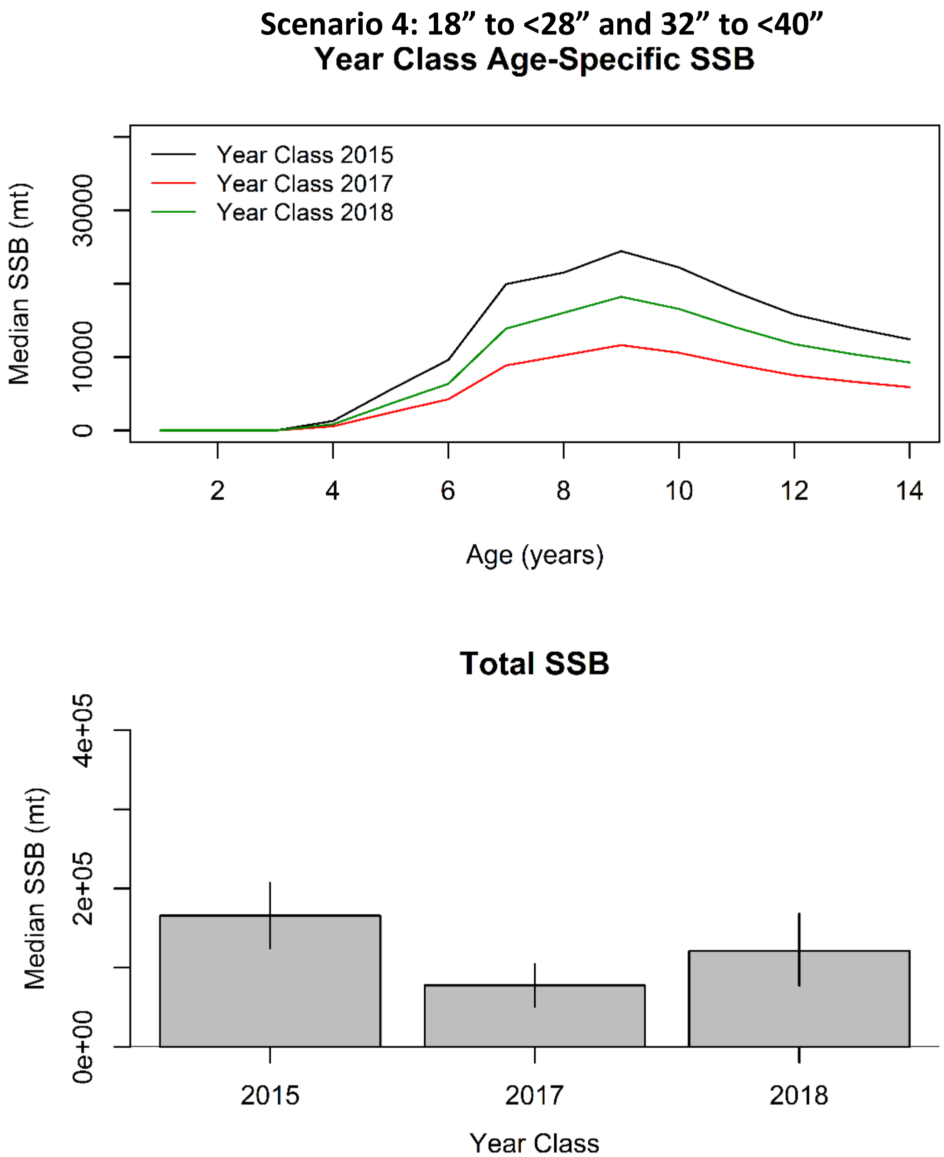


Figure 5. Age-specific (above) and total female spawning stock biomass (below) of the 2015, 2017, and 2018 year classes under scenario 4 (18” to <28” and 32” to <40”).

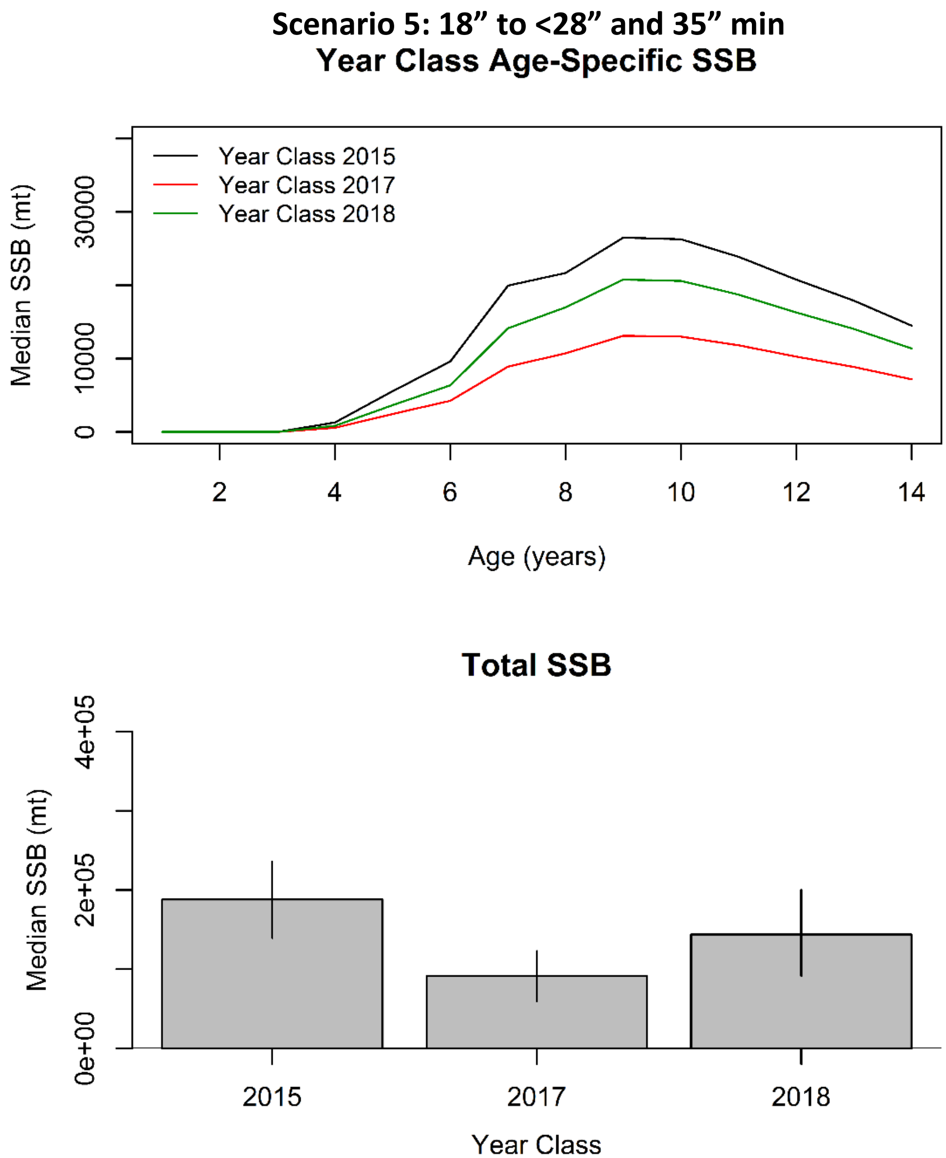


Figure 6. Age-specific (above) and total female spawning stock biomass (below) of the 2015, 2017, and 2018 year classes under scenario 5 (18” to <28” and 35” minimum size).

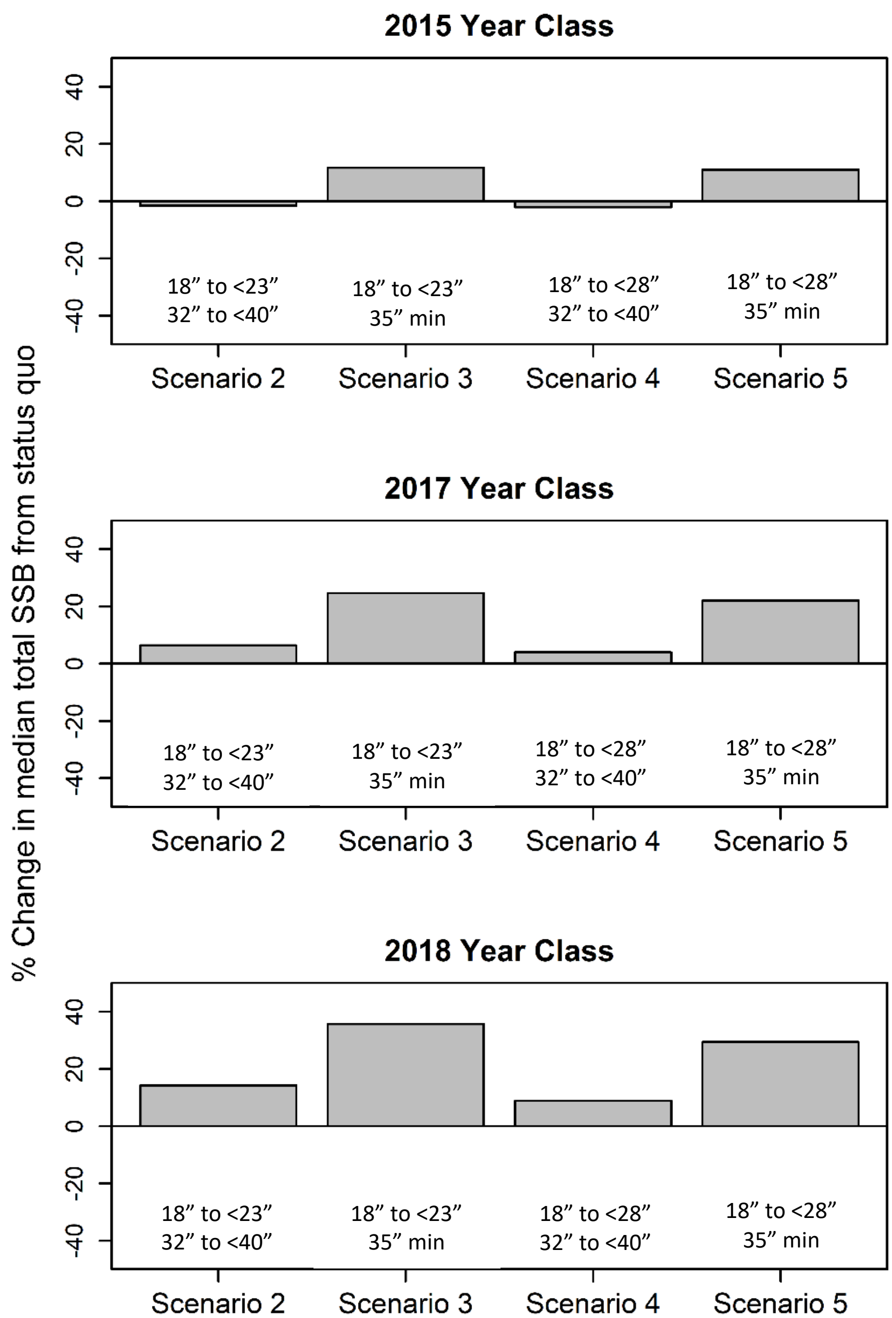


Figure 7. Change in total female SSB for each year class under scenarios 2-5 compared to scenario 1 (status quo).

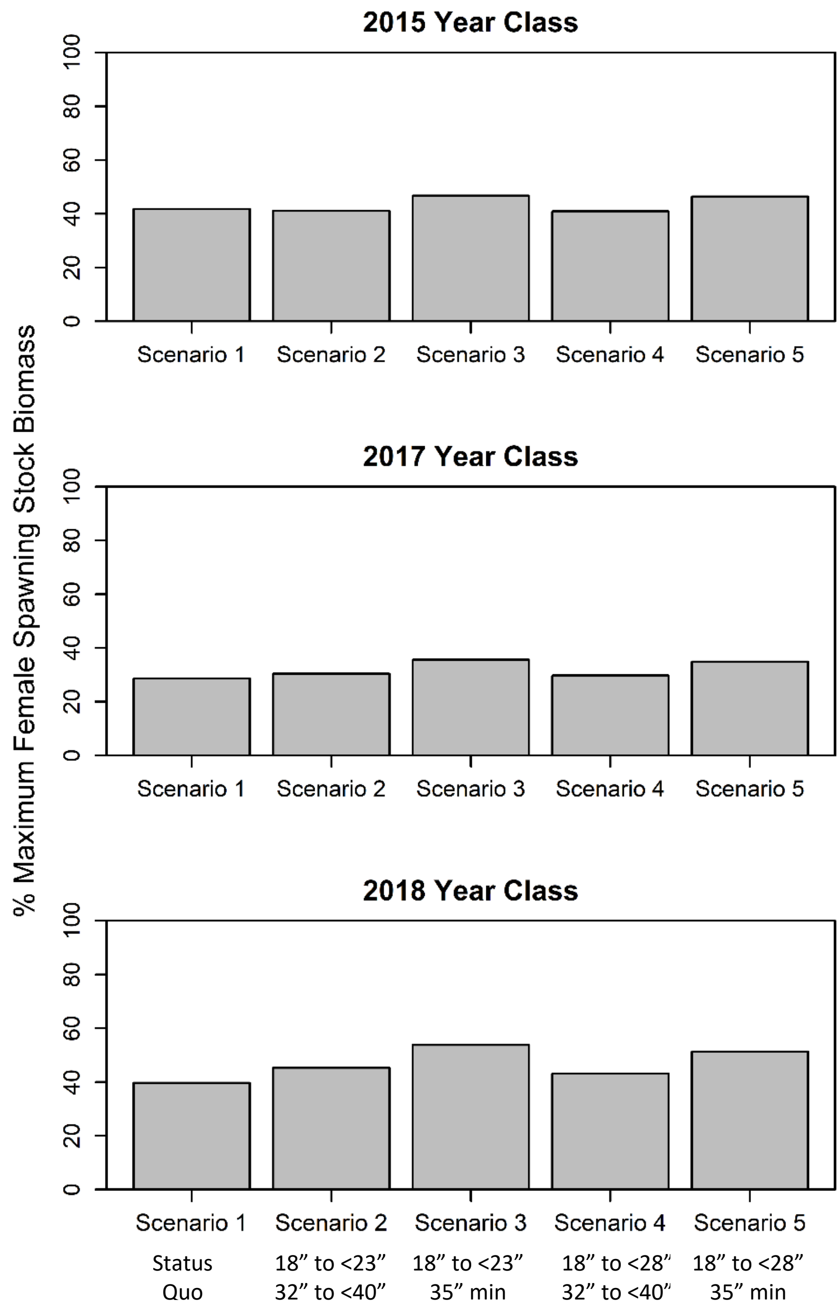


Figure 8. Percent maximum female spawning stock biomass under scenarios 1-5.

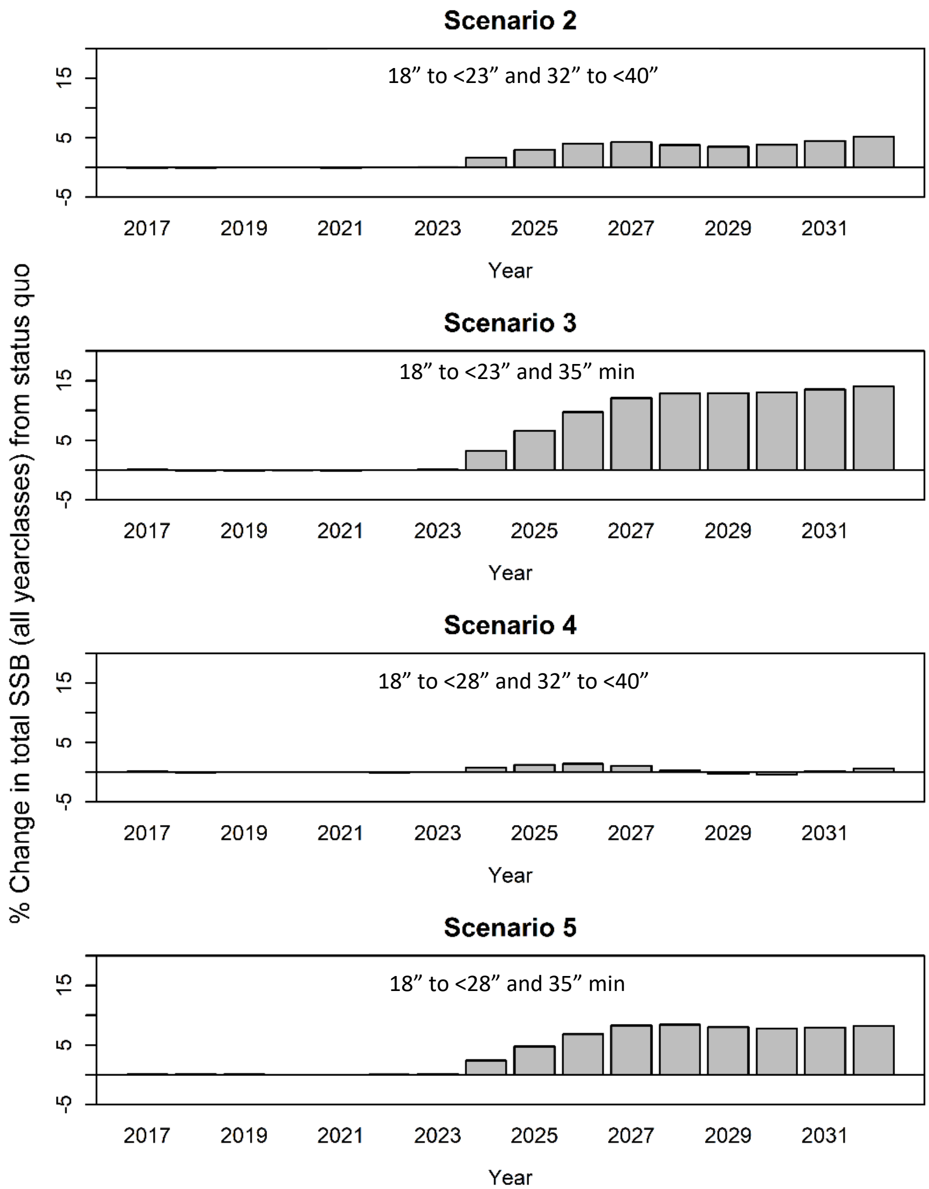


Figure 9. Change in total female SSB for all year classes under scenarios 2-5 compared to scenario 1 (status quo).

<u>Enclosed: OCEAN ONLY CHANGE Projections for Alternate Size Regulation Scenarios Using Weighted Selectivity Vectors (September 2021)</u>

The standard projection model from the assessment was used. Constant F scenarios with constant F = F target (0.197) starting in 2018 were examined. The starting year of the model was parameterized with the 2017 bias-corrected estimates of ages 1-15+ abundances and F. Error in these estimates was included, so that values for each run were re-sampled from normal distributions parameterized with estimates and corresponding standard errors from the SCA model.

Annual recruitment for years 2018-2021 were forecasted from the Maryland and New Jersey YOY indices for years 2017-2020 (lagged one year ahead) by using a multiple regression equation fitted to 1982-2017 SCAA age-1 numbers and the Maryland and New Jersey YOY indices (lagged ahead one year) for the same years. Variation was added to the forecasted values by resampling the vector of residuals from the model fit.

Annual recruitment for years > 2021 was generated from spawning stock biomass by using the "Hockey Stick" approach used in the 2018 benchmark. A Beverton-Holt SR equation is used to generate age-1 numbers if the previous year's female spawning stock biomass is less than the median SSB of 1982-2017 SCA estimates; otherwise, the median of recruitment estimates for 1982-2017 is used. Variation is added to a recruitment estimate by resampling the vector of residuals from the Beverton-Holt model fit.

Projections started at 2017 and ended at year 2032. The latter year was selected to allow the 2015, 2017, and 2018 year classes to reach age 14 (see below). Five thousand runs were made for scenario investigated.

<u>Scenarios</u>

Four scenarios of time-varying size regulations were examined:

		Period	
Scenario	Description	2020-2022	2023-2032
1	Status quo	28 to <35	28 to <35
2	Ocean Min Size	28 to <35	35 min
3	Ocean Larger Slot	28 to <35	32 to <40
4	Ocean Narrower Slot	28 to <35	28 to <32

The size limit scenarios were investigated by changing age-specific selectivity vectors over time. For year 2017, the selectivity vector from the SCA model was used, and for years 2018-2019, the average of selectivity for years 2015-2017 was used. Selectivity vectors for a 28" to <35" inch slot, minimum size of 35 inches, a 32" to <40" inch slot and 28" to <32" inch slot were developed by weighting the selectivities generated using Mike Celestino's app and the Bay-wide selectivity vector from 2018 assessment by relative F (F_{bay} versus F_{coast}) in 2017 (Figure 1).

Year-Class Contribution to Female Spawning Stock Biomass

Given age-1 estimates of abundance for year classes 2015 (SCA model), 2017 (forecast equation) and 2018 (forecast equation), the female spawning stock biomass in absence of fishing was calculated using the same projection equations. Error was added to the age-1 estimates by using the same methods as described above for the annual recruitment values. The median and 95% percentiles of the total SSB for age 1-14 were saved. Only SSB through age 14 was used because age 15 is a plus-group which represents multiple cohorts. In addition, changes in total SSB under scenarios 2-4 relative to scenario 1 (status quo) were examined.

For each scenario, median and 95% percentiles of age-specific and total SSB for each year class were saved. The medians of SSB from each scenario and under no fishing were used to compute the percentage of maximum SSB resulting from time varying regulations for each year class.

***Note**: The projections assume both the commercial and recreational sectors adopt the new slot limits.*

Results

The projections suggest female SSB will exceed the SSB threshold and target on the same timeframe under all scenarios, assuming the F target of 0.197 is maintained throughout all years.

Age-specific and total SSB for year classes 2015, 2017 and 2018 are shown in Figures 2-5 for each scenario. Under all scenarios, the SSB of year class 2015 is larger than the SSB of the 2017 and 2018 year classes, and 2018 SSB is larger than 2017. Under the 35- inch minimum (scenario 2) the size limit regulation change starting in 2023 increased SSB age-specific and total SSB for all year classes. Under a larger slot size (scenario 3), there was a slight increase in SSB for the 2017 and 2018 year classes. Only the 2015 year class benefitted slightly under the narrower slot limit (scenario 4).

These changes are more apparent when SSB from the alternative scenarios (2-4) are compared to the SSB from the 28” to <35” inch status quo (scenario 1) (Figure 6). The increase in minimum size to 35” (scenario 2) increased the total SSB for all year classes, although the benefit was greater for the younger age classes. Under scenario 3 (larger slot), the 2015 year class had a slight loss of SSB while the 2017 and 2018 year classes gained slightly more SSB. Under scenario 4 (narrower slot), only minor gains were achieved for the 2015 and 2017 year classes. The percentage of each year class’s SSB under each scenario is compared to its maximum potential under no fishing is shown in Figure 7. Under each scenario, the 2015 and 2018 year classes’ percent maximum SSB were greater than 40% under all scenarios; the percent maximum SSB for the 2017 year class was below 40% but above 20%.

Figure 8 shows the change in total female SSB for all year classes under the alternative scenarios compared to scenario 1 (28 to <35 inch status quo) for each year. Under scenario 2 (35 inch minimum), total SSB increased relative to the status quo, with a maximum increase of just over 4% at the terminal projection year of 2032. Total SSB also increased under scenario 3 (larger slot), but the maximum increase was less than 2%. Under scenario 4 (narrower slot), total SSB decreased with a maximum decrease of about 3% at the terminal projection year of 2032.

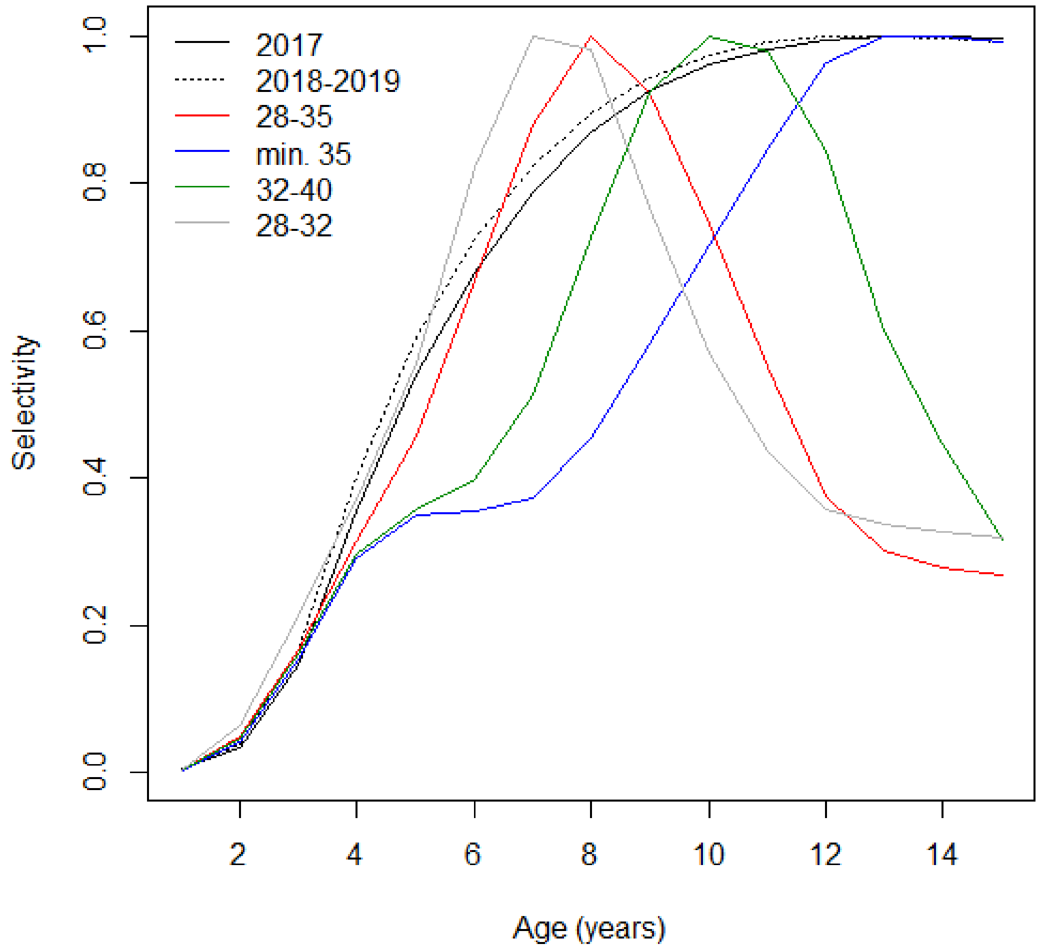


Figure 1. Age-specific selectivity values used in the projections under the four scenarios.

Scenario 1: Status Quo

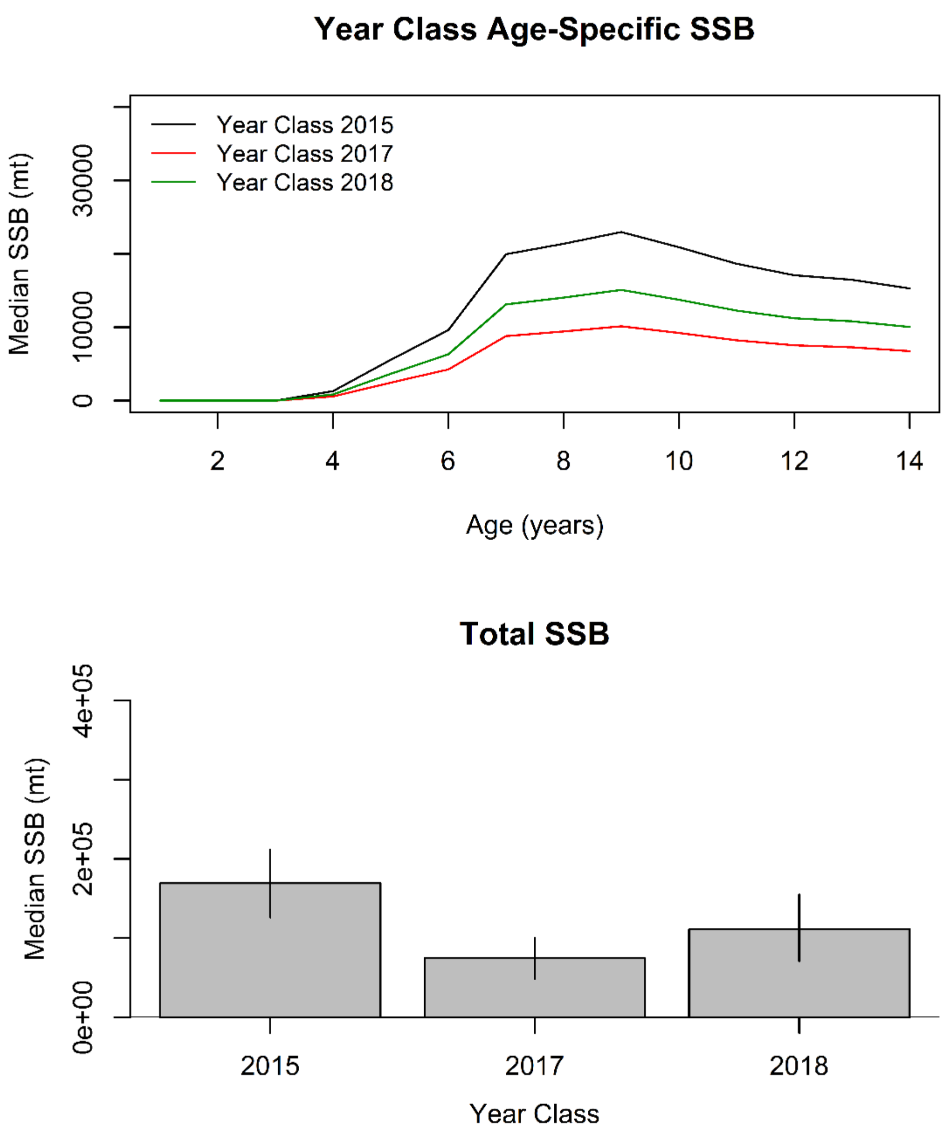


Figure 2. Age-specific (top) and total female spawning stock biomass (bottom) of the 2015, 2017, and 2018 year classes under scenario 1 (status quo).

Scenario 2: 35" minimum

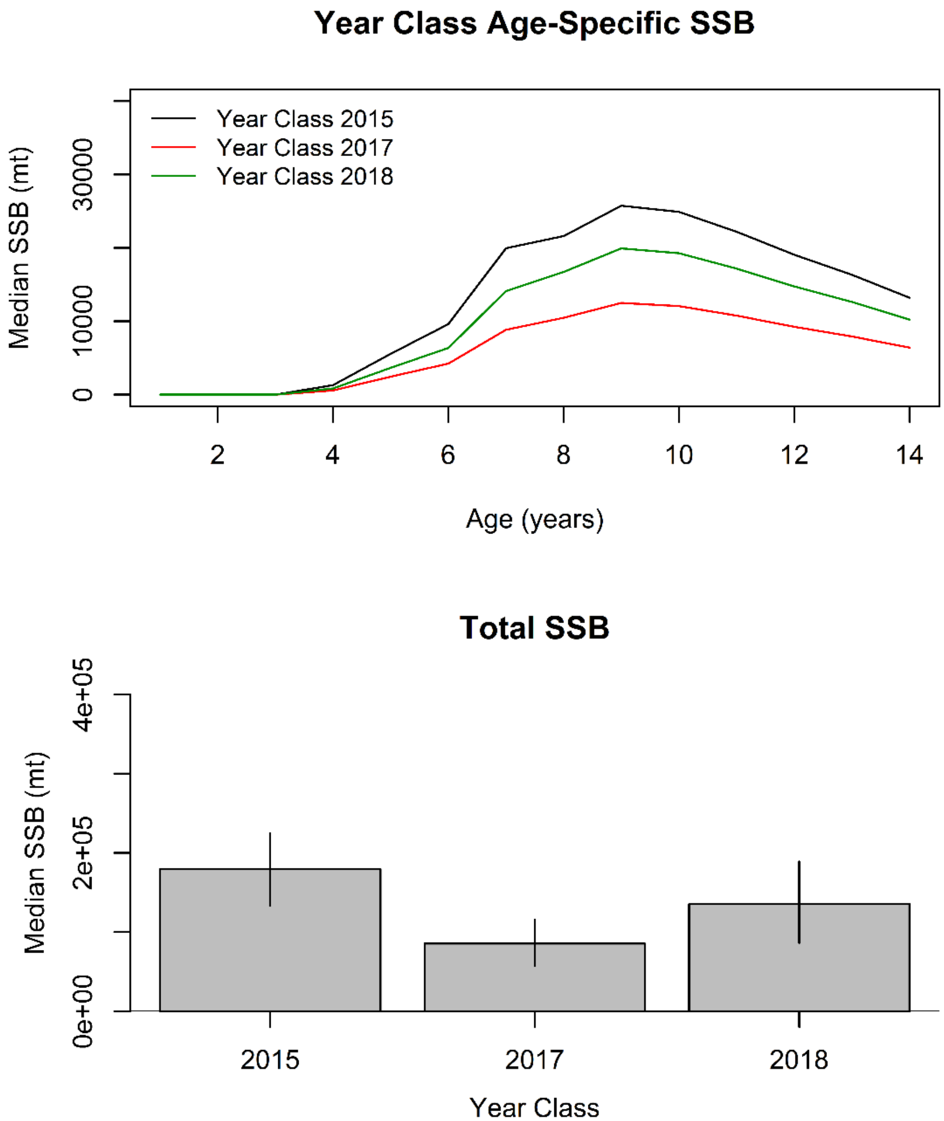


Figure 3. Age-specific (top) and total female spawning stock biomass (bottom) of the 2015, 2017, and 2018 year classes under scenario 2 (35" minimum size).

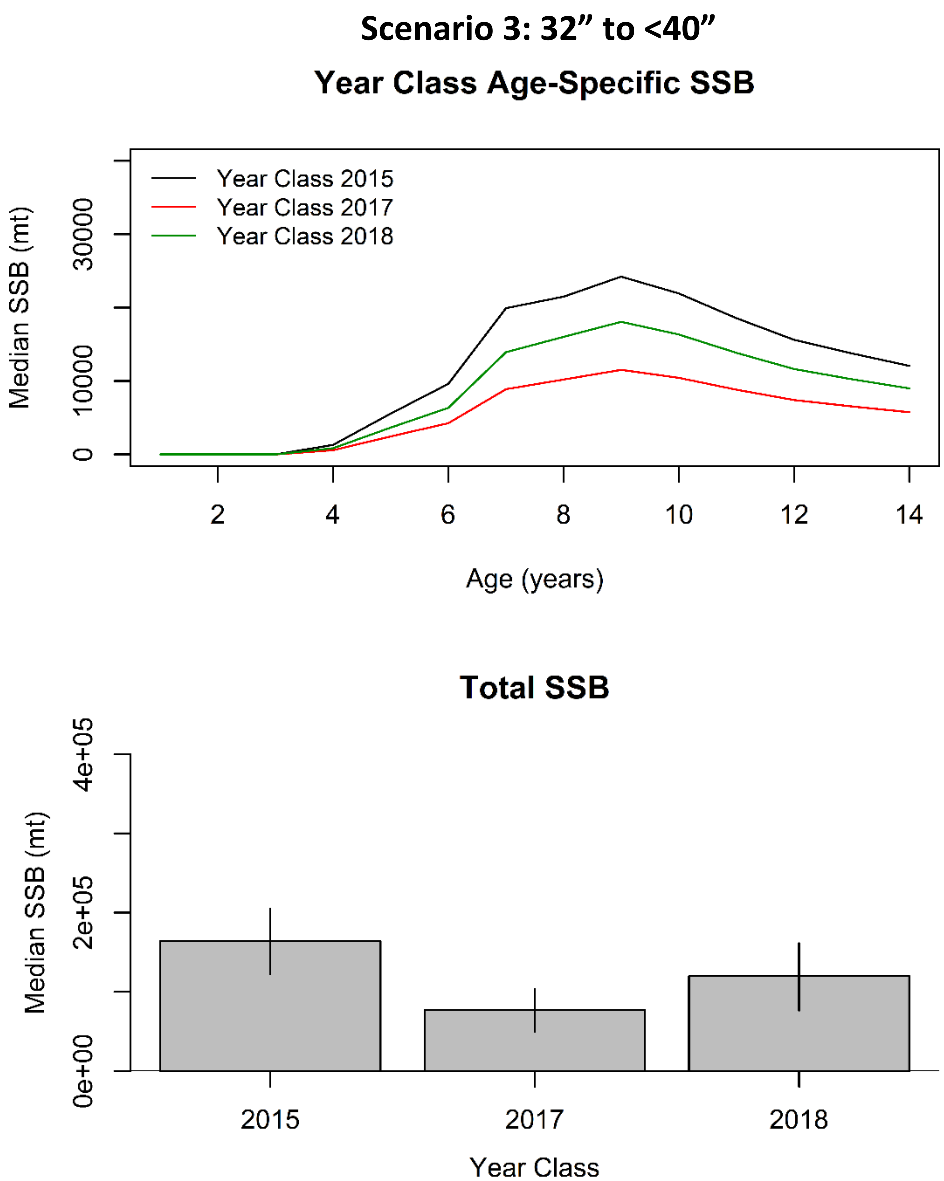


Figure 4. Age-specific (top) and total female spawning stock biomass (bottom) of the 2015, 2017, and 2018 year classes under scenario 3 (32" to <40" slot limit).

Scenario 4: 28” to <32”

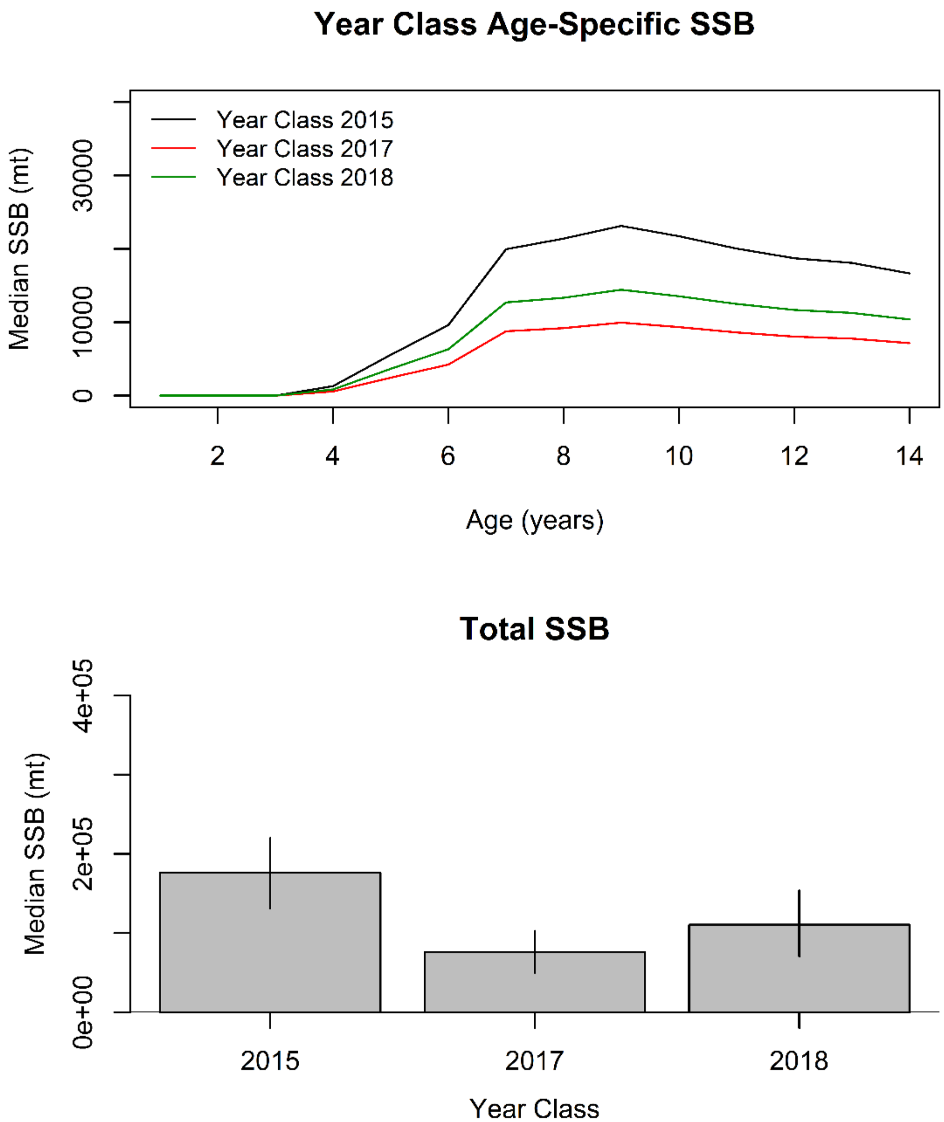


Figure 5. Age-specific (top) and total female spawning stock biomass (bottom) of the 2015, 2017, and 2018 year classes under scenario 4 (28” to <32” slot limit).

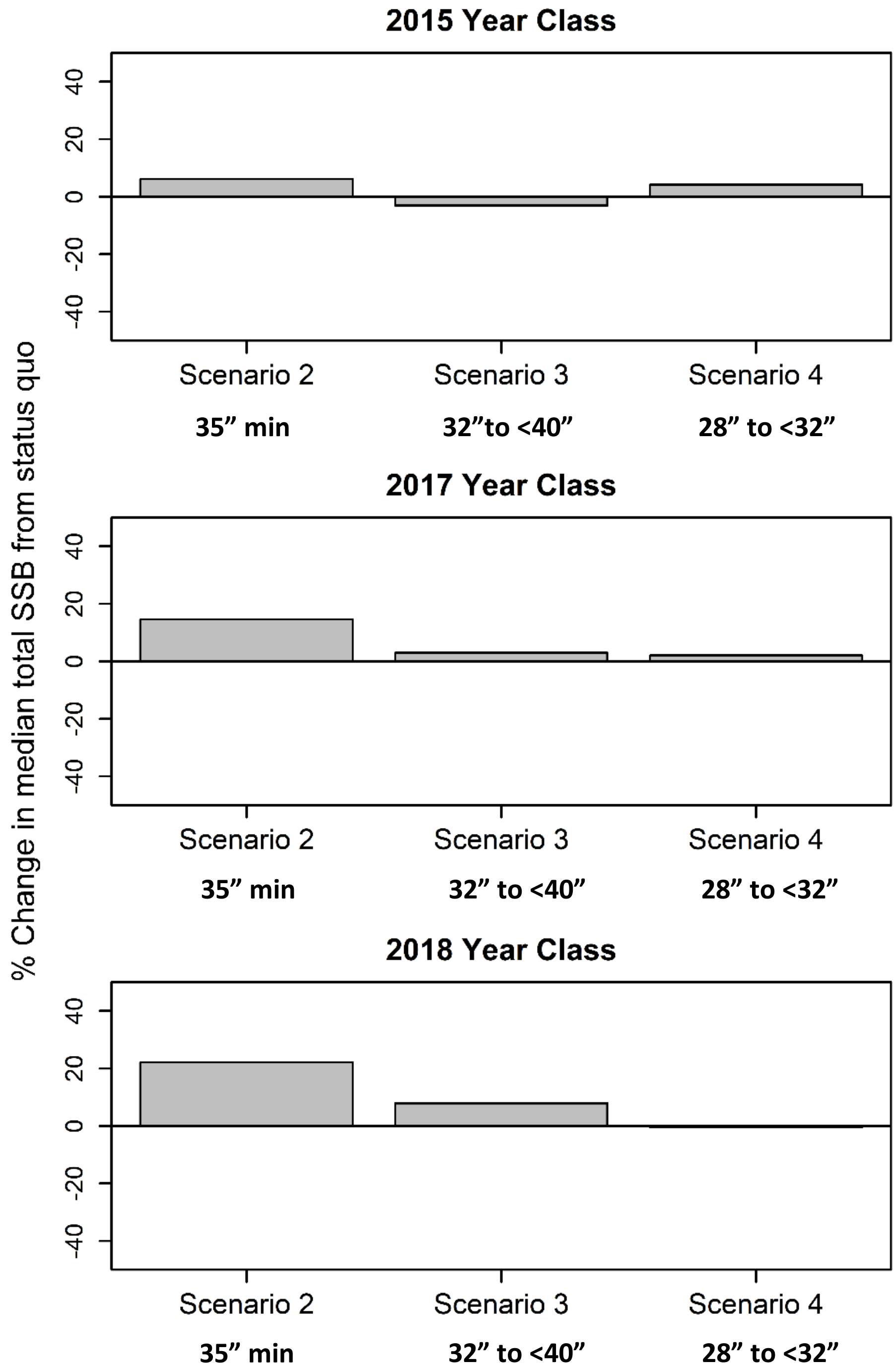


Figure 6. Change in total female SSB for each year class under scenarios 2-4 compared to scenario 1 (status quo).

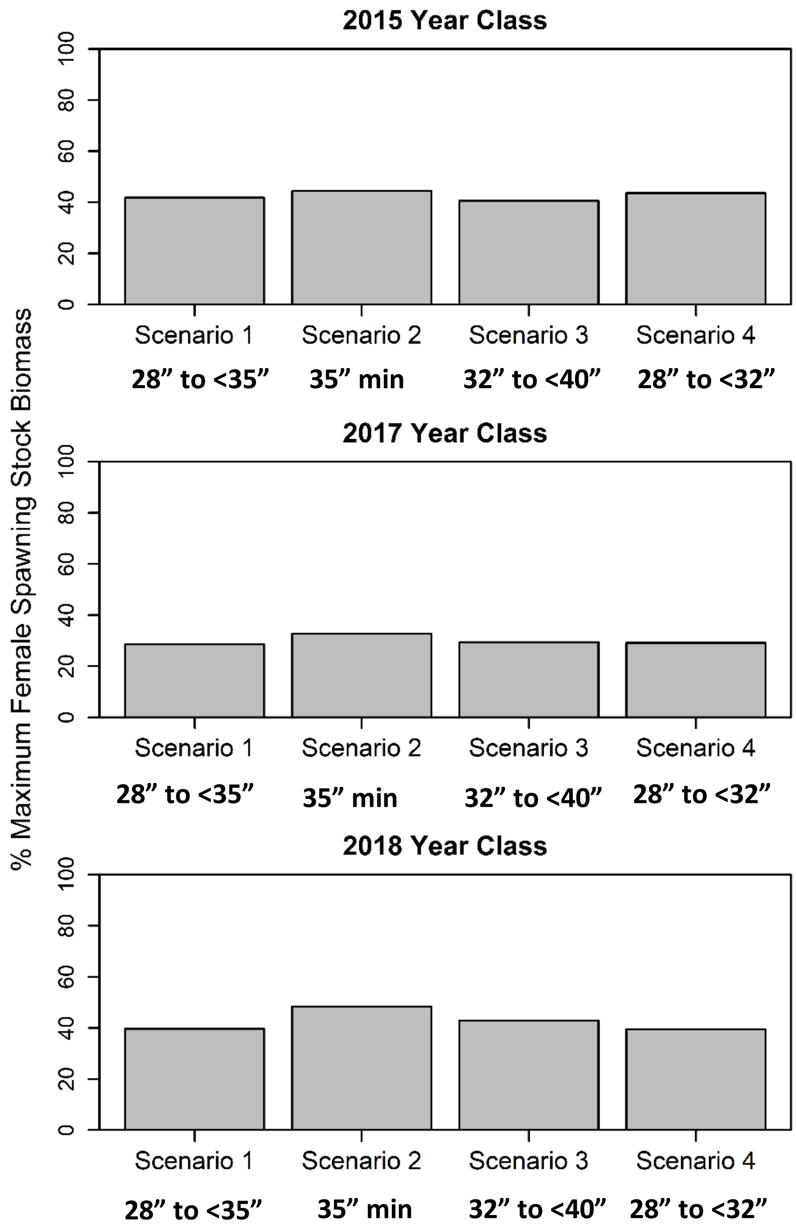


Figure 7. Percent maximum female spawning stock biomass under scenarios 1-4.

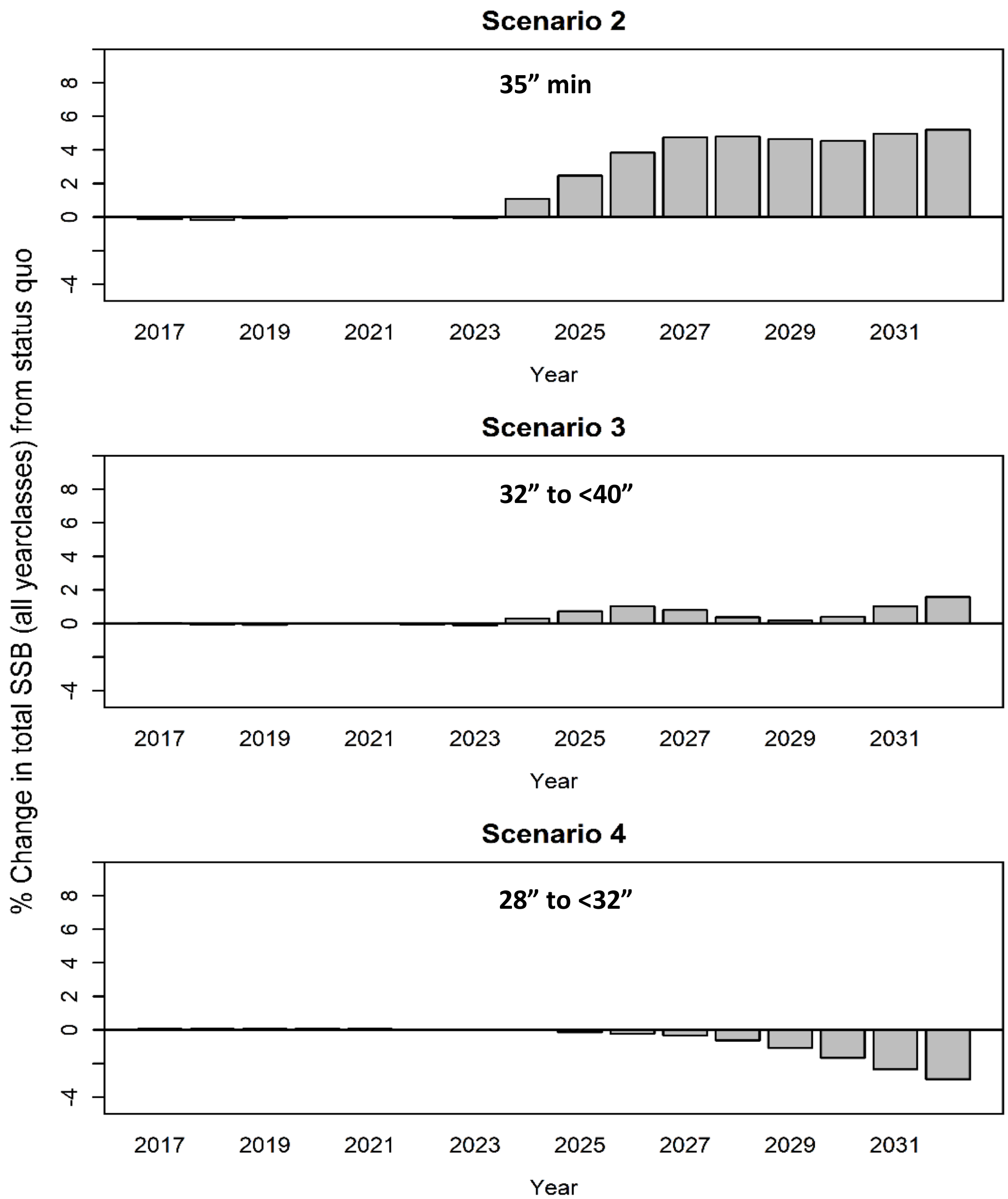


Figure 8. Change in total female SSB for all year classes under scenarios 2-4 compared to scenario 1 (status quo).