

Analysis of alternate minimum and maximum sizes as management options for Lobster Management Areas in the Gulf of Maine.

Report to the ASMFC Lobster TC and PDT.

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The Lobster TC provided analysis to the ASMFC Lobster Board ahead of the Spring 2021 meeting with estimated outcomes to the Gulf of Maine / Georges Bank lobster fishery given the implementation of alternative management measures (min and max gauge size), including changes to total weight of lobsters landed, number of lobsters landed, Spawning Stock Biomass and Exploitation. The analysis included an attempt to examine how fisheries in different LMAs would be affected though the population simulation model was not re-parameterized for each LMA. In discussions, we concluded that the simulations for LMA1 were probably reasonably accurate because:

1. Many of the inputs for the simulations are taken from the 2020 stock assessment. Because the vast majority of the landings come from LMA1, the stock assessment parameters are essentially already tuned to the parameters of the LMA1 fishery.
2. LMA1 is primarily a recruitment-based fishery in inshore or nearshore habitats and, therefore, likely to be representative of the full stock model.

However, there was concern that the offshore fishery in Lobster Management Area 3 was considerably different from the full stock model and, thus, may have inaccurate outcomes due to a mis-parameterized simulation model. The parameters for the Outer Cape Cod fishery are probably somewhere between LMA1 and LMA3 as it consists of both a resident lobster population and a seasonally-migrating population, moving between inshore and offshore habitats.

To address these differences between the LMAs in population simulations, we performed the following:

1. For the LMA1 simulations, we used the stock assessment parameters as the inputs.
2. For LMA3 simulations, we attempted to manually tune the population simulation model to match the catch characteristics of the LMA3 fishery, under the assumption that a simulation model that could reproduce the catch characteristics of the fishery may more accurately project changes in the fishery given changing management measures.
3. For the OCC simulations, we ran two sets of simulations, using the input parameters for both LMA1 and LMA3 under the assumption that this bounds the dynamics we might see in OCC.

For all simulations, populations were initiated with zero abundance and run for 50 years with constant recruitment to allow population abundances and length comps to reach equilibrium. The equilibrium populations were then compared across the various legal selectivity scenarios to determine the effect of these different management alternatives.

For a simple, model-free analysis of the fishery catch composition for LMA1 and LMA3, we calculated the cumulative proportion of catch by weight at length by converting catch-at-size to weight-at-size and weighting for unequal sex ratios and seasonality of landings.

LMA1 Simulations

The input parameters for the LMA1 simulations were primarily drawn from the 2020 stock assessment. This includes the recruitment seasonality, length composition and sex ratio, growth model, gear, legal and conservation selectivities and mean estimated fishing mortality from the terminal years.

LMA1 Results

The cumulative catch weight-by-length curve indicates that the mean size of lobsters landed in the LMA1 fishery is within the smallest legal size bin (83-91mm, Figure 1). Nearly 90% of the catch are below 100mm CL and only about 2% of the catch are over 120mm CL. This supports the perspective that LMA1 landings involve a narrow range of small lobster sizes and is primarily a recruitment-dependent fishery.

Increasing the minimum legal size is projected to decrease the total number of lobsters landed but result in a net increase in yield-per-recruit (YPR) and total weight of catch (Table 1 and 2). However, the magnitude of these changes are small enough that they may not be detectable in the actual fishery given inter-annual variations in recruitment and catch. Changing the maximum legal size is projected to have very little effect on either catch number or weight.

Note that these are purely yield-per-recruit simulations so recruitment subsidies from increased SSB are not assumed in the calculations of catch weight or number so, thus, probably represent a conservative, lower bound. A less conservative upper bound would be the product of change in YPR and the change in SSB.

Increasing the minimum legal size is projected to result in large increases in SSB (Table 3). Minimum legal sizes that approach or exceed the size of maturity produce increasing returns on SSB as this allows a much larger portion of the population to reproduce at least once. Thus, increasing minimum legal size to 88mm is projected to result in a near doubling in SSB. Increasing maximum size can result in a large decrease SSB, particularly as the minimum legal size increases and more of the population survives to reach the current maximum legal size.

Increasing legal size would result in moderate to large decreases in exploitation as more of the stock becomes protected (Table 4) with exploitation decreasing by nearly 30% at a minimum legal size of 88mm. As with catch weight and number, changing maximum legal size has little effect on exploitation rates as these sizes represent a very small portion of the LMA1 population.

LMA3 Simulations

We first analyzed the port and sea sampling data provided for the 2020 benchmark assessment but constrained to LMA3 to estimate fishery characteristics, including catch size composition, catch sex ratio, and conservation selectivity (discarding due to egg-bearing or v-notch status).

We then specified the conservation selectivity from the biosamples and current legal selectivity appropriate for LMA3 in the population simulation model and iteratively tuned the following parameters:

1. Fully-selected fishing mortality, assumed constant across seasons
2. Recruitment sex ratio

3. Recruitment size composition for each sex.

For a given tuning run, the population simulation model was provided an updated set of input parameters and projected forward 25 year to reach equilibrium. The resulting catch composition from the model run was then compared to the average catch composition from the last five years of the biosamples to determine accuracy of the simulation models. Comparisons were conducted both visually for obvious lack-of-fit and by correlating the simulated and observed catch compositions. Correlations were performed on both the catch proportions and logit-transformed catch proportions, the latter to place more emphasis on length compositions that occur in smaller proportions.

Once the model was tuned to perform as well as might be expected, given minor, seasonal lack-of-fit that could not be easily resolved, the simulation model was then run with the tuned parameters for all combinations of proposed minimum and maximum size limits. We then summarized the outputs from the different simulations as values relative to the current minimum and maximum size regulations in place for LMA3.

Results

The cumulative catch weight-by-length curve indicates that 110 mm carapace length is the approximate mean size of lobsters landed in the LMA3 fishery (Figure 1). However, the cumulative curve is nearly linear from 90mm through 130mm, indicating lobsters across this size range are about equally important to the landings of this fishery. Lobsters less than about 92mm constitute the lower 10% quantile of landings while lobsters greater than 136mm constitute the upper 10% quantile with lower and upper quartiles around 98mm and 123mm respectively. This suggests that LMA3 landings include a broad range of lobster sizes, unlike typical inshore lobster fisheries that are primarily recruitment-driven.

The final tuned parameters included a quarterly fishing mortality of 0.1 (0.4 total annual mortality) and a 70:30 female to male recruitment sex ratio. The tuned recruit length compositions are bi-modal for both sexes, indicating recruitment to the fishery comes both from growth of smaller individual within the LMA and immigration from outside the LMA (Figure 2). With these compositions, about 80% of male recruitment and 30% of female recruitment is attributed to growth with the remainder of new individuals coming from immigration from outside the LMA.

Fitting the simulation length comps by manually tuning these parameters resulted in reasonably good fits to the observed length compositions (Figures 3, 4, and 5). Some lack-of-fit is still evident within seasons but this lack-of-fit is generally contrary to the lack-of-fit observed in other seasons, making it difficult to further improve the fit with just the parameters of interest. Correlations between observed and predicted compositions were 0.981 for simple proportions and 0.97 for logit-transformed proportions, suggesting both high and low proportion values for observed length comps are well matched by the simulation and we deemed this adequate to a basis to examine alternative management options.

Decreasing either the minimum or maximum legal size is projected to decrease total weight of catch (Table 5). However, contrary to the previous analysis for the full stock or inshore LMA's, changes to the maximum size have much larger impacts on landings than changes to the minimum size, particularly once the maximum size drops to between 140 and 150mm. Decreasing the maximum size from 171mm

to 127mm is projected to decrease landings by about 30% while decreasing the minimum size from 90mm to 83mm is only projected to decrease landings by a couple of percent.

Decreasing the minimum legal size is projected to marginally increase the number of lobsters being landed but decreasing the maximum size marginally to moderately decreases the number of lobsters landed, producing neutral effects for many of the management options explored here (Table 6).

Decreasing maximum legal size from current regulations is projected to increase spawning stock biomass (SSB), possibly significantly, but decreasing minimum sizes would decrease SSB (Table 7). The greatest observed increase would be from holding the minimum size at current values but maximally decreasing maximum sizes, essentially narrowing the length range where lobsters are legal, which is estimated to result in a 64% increase in spawning stock. As above, changes to maximum size have bigger effects on SSB than changes to minimum sizes.

Decreasing maximum sizes would result in a decrease in exploitation but decreasing minimum sizes would increase exploitation (Table 8), countering each other and paralleling patterns observed for SSB. Because the calculation of exploitation is based on numbers of individuals rather than mass, decreasing minimum sizes have larger effects on exploitation than observed above for landings or SSB. Again, changes in exploitation increase rapidly with decreasing maximum sizes once the alternate maximum gauge size reaches a size that includes a significant portion of the catch for the LMA.

OCC Simulations

Due to time and data constraints, we did not attempt to tune a simulation model for OCC. Rather, we assume that population dynamics and fishing mortality rates in OCC are bounded by the conditions observed in the LMA1 and LMA3 fisheries. Thus, we ran simulations for OCC using the OCC legal size range with both the LMA1 and LMA3 parameterizations and present both sets of results with the understanding that results for OCC should fall between these extremes.

In general, outputs (catch weight, number, SSB and exploitation) show different responses for the LMA1 than the LMA3 parameterizations. LMA1 parameterizations tend to produce simulations that are very sensitive to changes in minimum legal size but not maximum legal size, while simulations with LMA3 parameterization only slightly sensitive to changes in minimum legal size but moderately to highly sensitive to changes in maximum legal size.

Total weight of landings is projected to be sensitive to changing minimum legal size with the LMA1 parameterization but be insensitive with the LMA3 parameterization (Table 9 A & B). With the LMA1 parameterization, decreasing minimum size is projected to decrease landings by ~5% while increasing legal size to 88mm would increase landings by 8%. Conversely, landings weight is insensitive to changes in maximum legal size for the LMA1 parameterization but sensitive to changes for the LMA3 parameterization.

Total catch number simulations shows trend similar to catch weight with the LMA1 parameterization being sensitive to changes in minimum size and the LMA3 parameterization sensitive to changes in maximum size (Figure 10 A & B). The pattern otherwise holds that larger minimum legal sizes result in lower catch numbers.

For SSB, the LMA1 parameterization is responsive to both changes in minimum and maximum legal size while the LMA3 parameterization is more sensitive to changes in maximum size (Figure 11 A & B). For example, decreasing minimum legal size to 127mm would increase SSB by between 24% and 65% for the LMA1 and LMA3 parameterizations, respectively. The ranges of minimum size tested in simulations produce changes in SSB in the range of -26% to +76% for the LMA1 parameterization and -1% to +6.8% for the LMA3 parameterization.

Decreasing minimum legal size produce increases moderate to small increases in exploitation (16% to 4% for LMA1 and LMA3 parameterizations, respectively, Figure 12 A & B). Either increasing minimum legal size or decreasing maximum legal size decrease serve to decrease exploitation with a maximum decrease of ~39% observed at the largest minimum and smallest maximum size and the LMA3 parameterization.

Discussion

There is a stark difference in cumulative landings by size between LMA1 and LMA3. LMA1 is clearly a recruitment-based fishery that would be highly sensitive to variations in recruitment. The LMA3 fishery, in contrast, is fishing a broad range of lobster sizes, and therefore ages, and is thus somewhat buffered from interannual variation in recruitment dynamics.

The LMA1 fishery is highly sensitive to changes in minimum legal size because of high exploitation rates on newly-recruited lobsters. The range of minimum sizes tested in simulations encompasses size range that represents the majority of landings for the inshore / nearshore fishery. Thus, changes to minimum size would dramatically change the length composition of the catch. Increases in the minimum size will have temporarily but significantly depress landing in the years immediately after are implemented but the benefits to SSB would be similarly immediate. Increasing the minimum legal size can add to the resilience of the fishery by marginally increasing the spread of effort across multiple year classes and significantly increasing SSB and egg production which may buffer the effects in any future change in productivity.

Generally, decreasing maximum gauge sizes have larger effects for LMA3 both relative to decreasing minimum sizes in LMA3 or for changing maximum sizes for the other LMAs. This matches the conclusions based on the cumulative catch curve (Figure 1) that showed that the LMA3 fishery lands a much broader size range of individuals than the inshore LMAs, with the upper portion of length compositions overlapping proposed alternative maximum sizes.

This analysis for LMA3 matches previous analysis conducted for inshore LMAs, finding that larger minimum legal sizes had positive effects across population parameters including higher catch weights, increased SSB and decreased exploitation. However, decreasing maximum legal sizes has mixed effects, decreasing immediate landings but increasing SSB, potentially by a larger margin. Because recruitment subsidies from increasing SSB are not included in this simulation, the net effect of these two opposing changes are uncertain. While decreasing maximum legal sizes would decrease immediate landings and make a larger portion of the population inaccessible to the fishery permanently (i.e. excluded lobsters won't grow into a legal size in the future), this increase in SSB may eventually produce a recruitment subsidy that could offset this loss of catch. The net effect would depend on multiple factors including the connectivity of the added SSB to larval settlement habitat and the migration patterns of these large females into adjacent habitats including inshore Gulf of Maine and international waters.

Finally, it is important to note the importance of large female lobsters that dominate the landings for much of LMA3. This both highlights the partial dependence of this fishery on immigration from adjacent habitats and adds uncertainty to this analysis. The growth and molt cycling of such large females is poorly understood and are not particularly well informed in the current growth model. Thus, the tuned parameters may be biased by mis-specification of the growth model and results in this analysis may be sensitive to the growth model used in some cases. Interpretation of tuned parameters and confidence in the precise results of this analysis should be taken with some caution. However, the general patterns of changing catch, SSB and exploitation with changes in minimum and maximum legal sizes is consistent across this and previous analyses so may be treated with higher confidence.

Cumulative Distribution of Catch Weight by Size

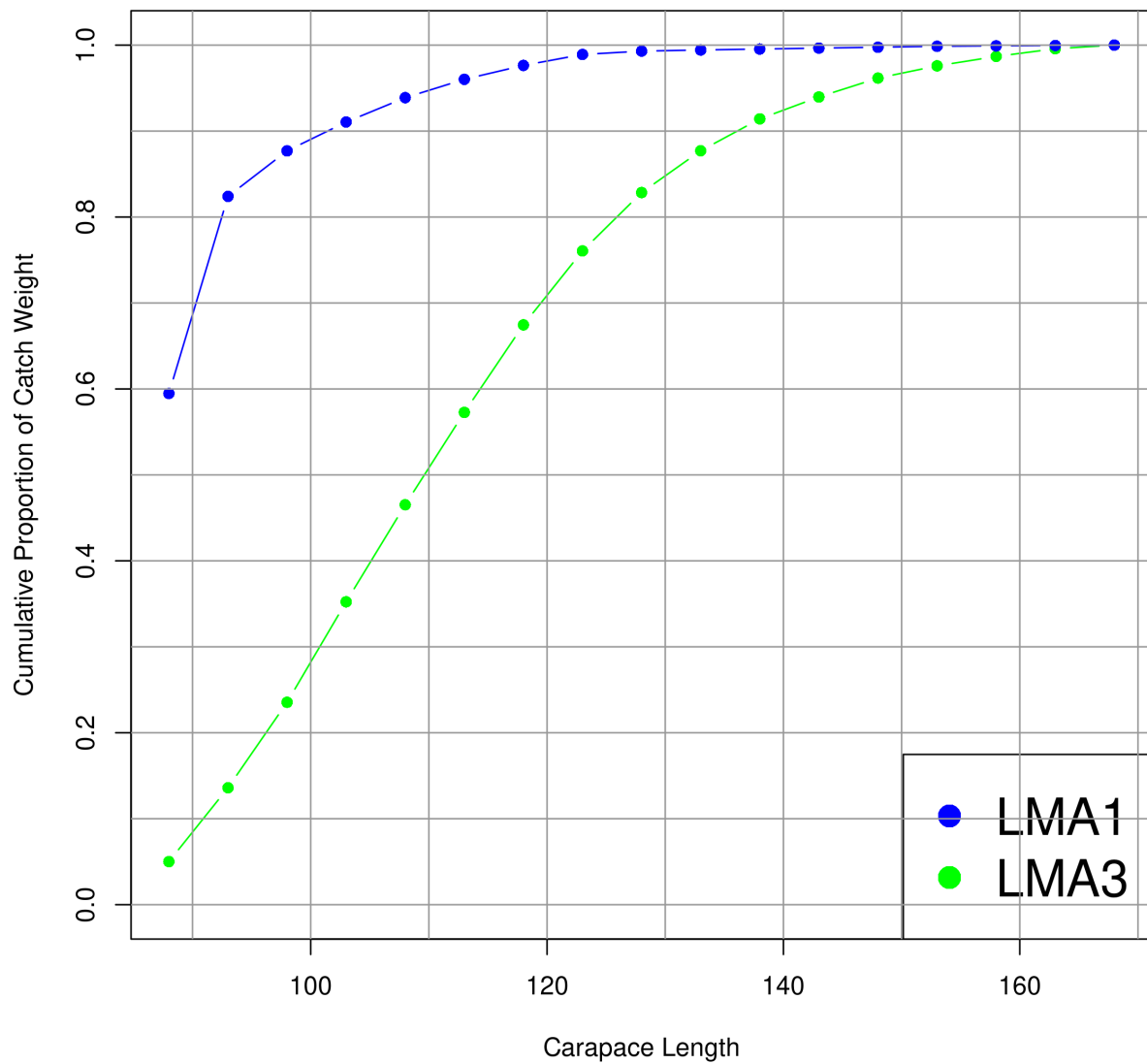


Figure 1. Cumulative proportion of catch weight by carapace length. To interpret, lobsters less than 90mm constitute approximately 8% of landings, while lobsters less than 130mm constitute approximately 85% of landings.

Recruit proportions for tuned population model

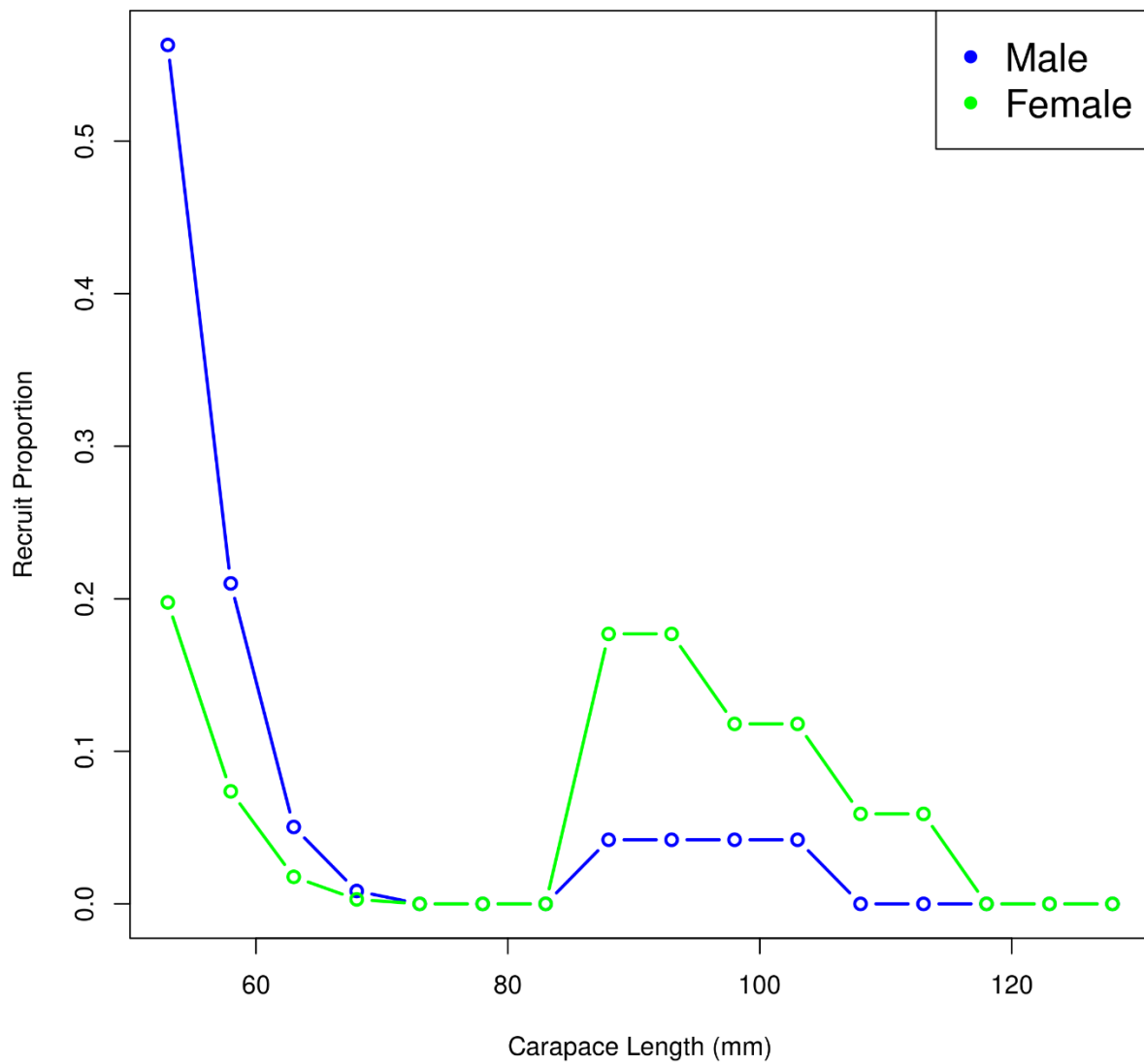


Figure 2. Tuned recruitment length compositions for the fitted model. The bi-modal length distribution suggests a combination of recruitment by growth (individuals <70mm) and migration (individuals >85 mm) with males primarily recruiting by growth and females primarily recruiting by migration as mature adults.

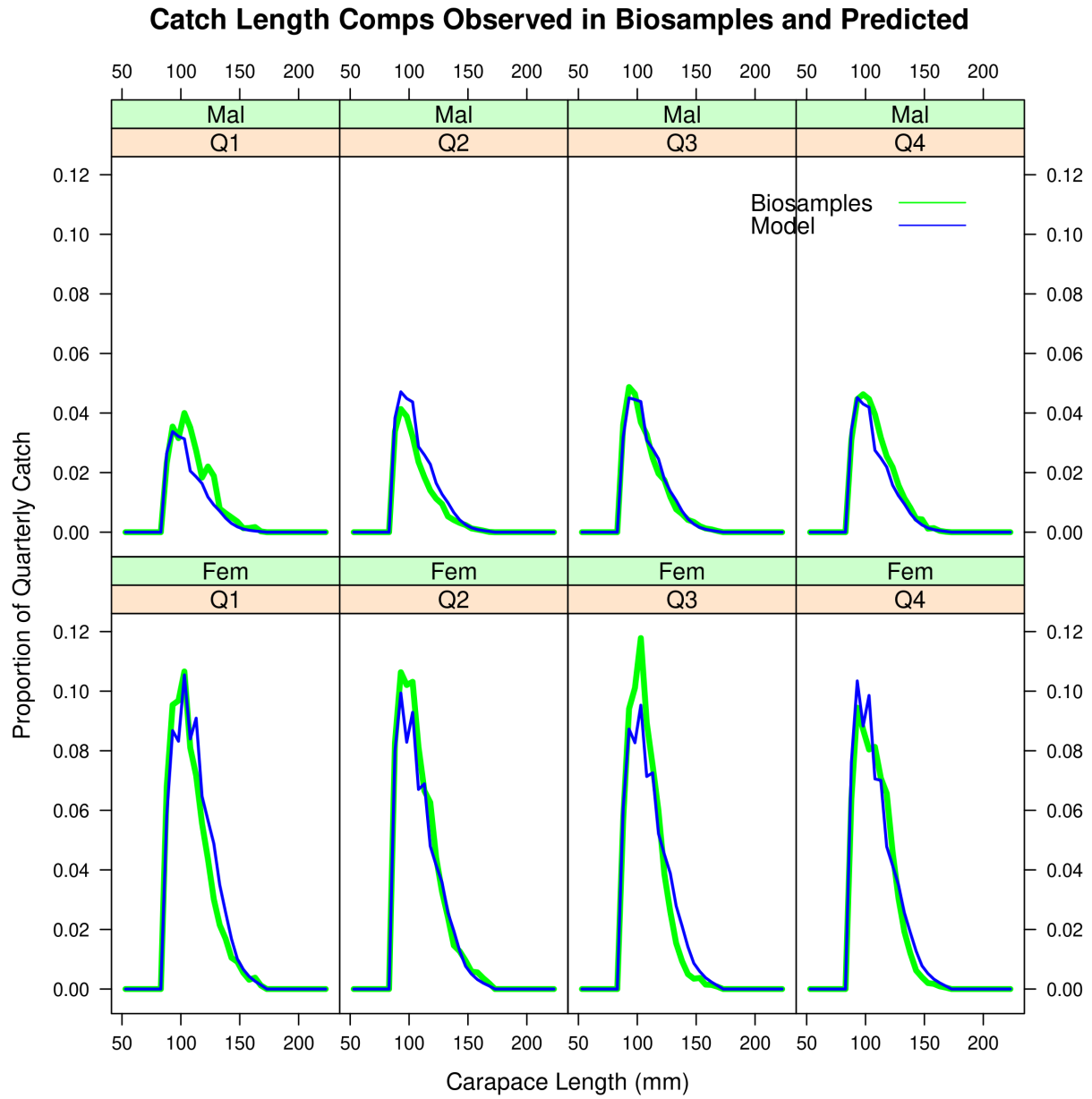


Figure 3. LMA 3 catch length compositions by sex and quarter based on biosampling and from the tuned population model.

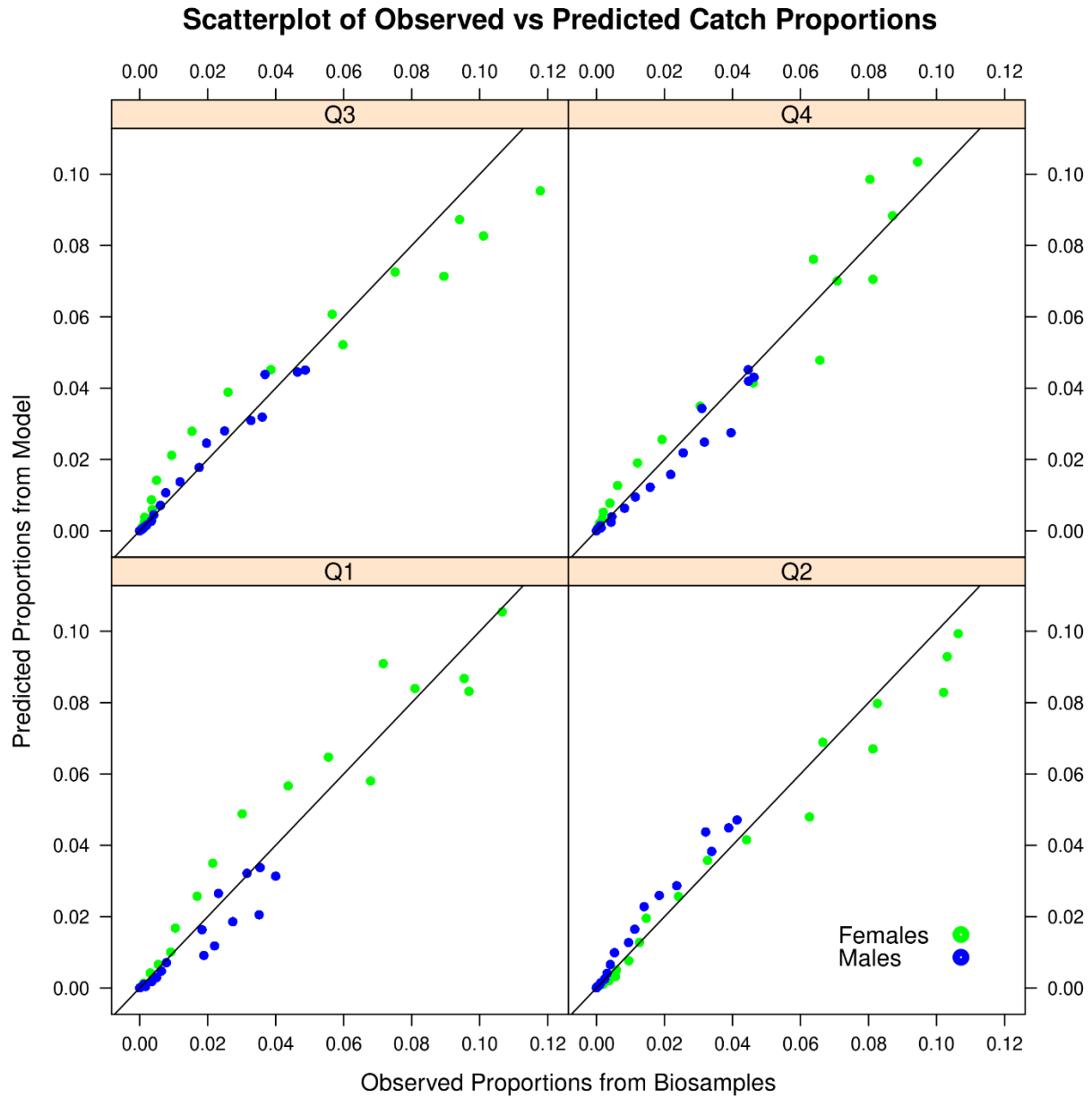


Figure 4. Relationship between length composition proportions observed in biosamples and predicted in the tuned population model by quarter and sex. The diagonal 1:1 line shows an ideal fit between the data sets.

Scatterplot of Observed vs Predicted Catch Proportions in Logit space

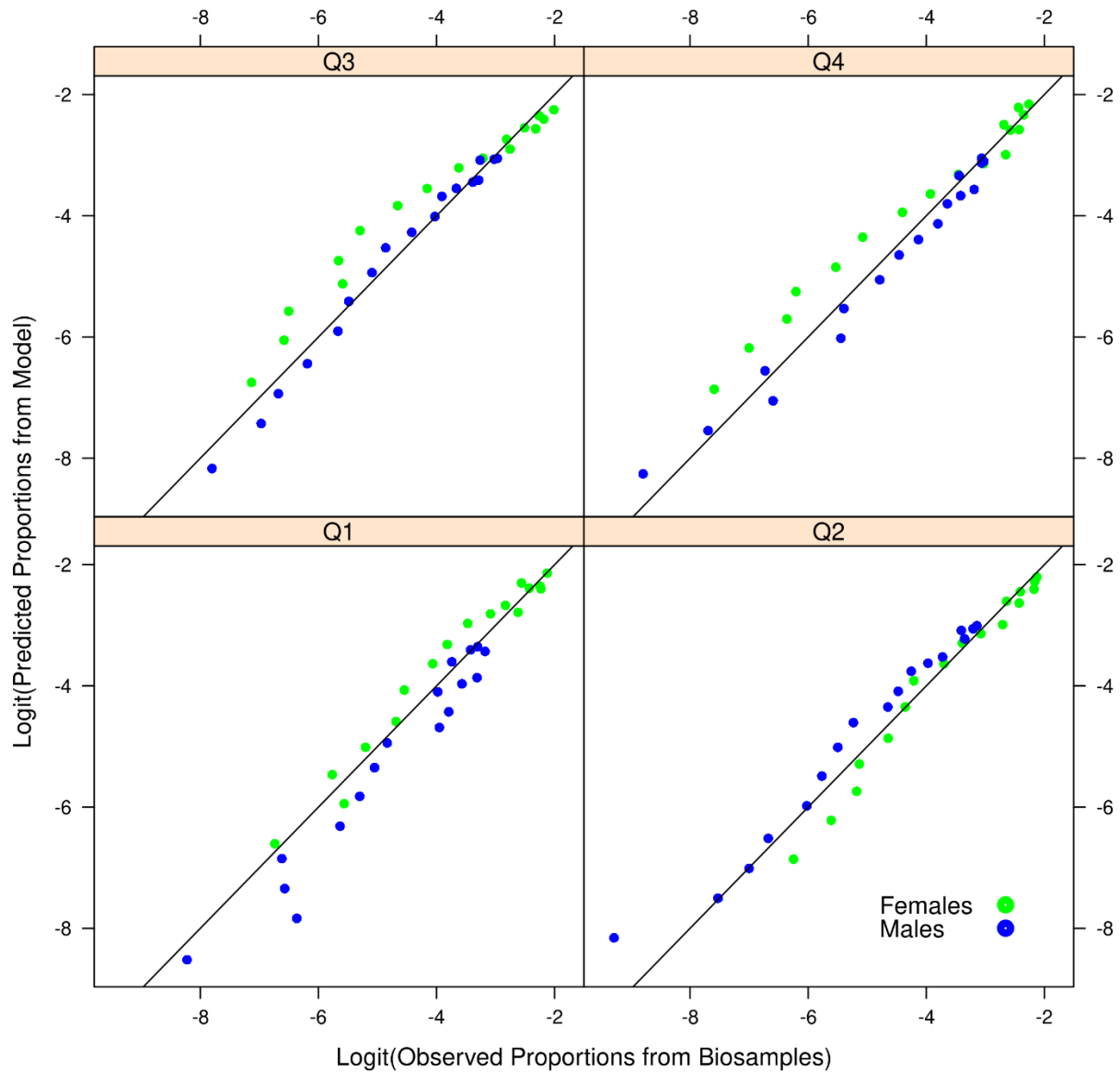


Figure 5. Relationship between length composition proportions observed in biosamples and predicted in the tuned population model by quarter and sex. Data points are logit-transformed to emphasize fit to lengths that occur in low proportions. The diagonal 1:1 line shows an ideal fit between the data sets.

Table 1. LMA1 projected relative changes to Weight of Landings resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	0.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
	3.31in / 84mm	3.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
	3.38in / 86mm	5.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
	3.47in / 88mm	13.00%	14.00%	14.00%	14.00%	14.00%	14.00%	14.00%
	3.53in / 90mm	14.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%
	3.594in / 91mm	16.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%

Table 2. LMA1 projected relative changes to Number of lobsters Landed resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	0.00%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%
	3.31in / 84mm	-2.00%	-1.80%	-1.80%	-1.80%	-1.80%	-1.80%	-1.80%
	3.38in / 86mm	-3.60%	-3.30%	-3.30%	-3.30%	-3.30%	-3.30%	-3.30%
	3.47in / 88mm	-8.50%	-8.10%	-8.00%	-8.00%	-8.00%	-8.00%	-8.00%
	3.53in / 90mm	-9.50%	-9.00%	-9.00%	-9.00%	-9.00%	-9.00%	-9.00%
	3.594in / 91mm	-11.30%	-10.80%	-10.70%	-10.70%	-10.70%	-10.70%	-10.70%

Table 3. LMA1 projected relative changes to Spawning Stock Biomass resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	0.00%	-16.50%	-18.30%	-18.50%	-18.50%	-18.60%	-18.60%
	3.31in / 84mm	19.00%	-1.40%	-3.60%	-3.80%	-3.90%	-3.90%	-3.90%
	3.38in / 86mm	38.00%	13.90%	11.30%	11.00%	10.90%	10.90%	10.90%
	3.47in / 88mm	98.00%	61.00%	56.90%	56.60%	56.50%	56.40%	56.40%
	3.53in / 90mm	117.00%	75.80%	71.30%	70.90%	70.70%	70.70%	70.70%
	3.594in / 91mm	151.00%	101.70%	96.40%	95.90%	95.70%	95.70%	95.60%

Table 4. LMA1 projected relative changes to Exploitation resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	0.00%	0.80%	0.80%	0.80%	0.80%	0.80%	0.80%
	3.31in / 84mm	-8.50%	-7.70%	-7.60%	-7.60%	-7.60%	-7.60%	-7.60%
	3.38in / 86mm	-14.40%	-13.60%	-13.50%	-13.50%	-13.50%	-13.50%	-13.50%
	3.47in / 88mm	-29.40%	-28.40%	-28.30%	-28.30%	-28.30%	-28.30%	-28.30%
	3.53in / 90mm	-32.10%	-31.00%	-30.90%	-30.90%	-30.90%	-30.90%	-30.90%
	3.594in / 91mm	-36.50%	-35.40%	-35.30%	-35.20%	-35.20%	-35.20%	-35.20%

Table 5. LMA3 projected relative changes to Weight of Landings resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	-31.30%	-14.60%	-6.30%	-4.20%	-2.80%	-2.10%	-0.80%
	3.31in / 84mm	-31.20%	-14.30%	-6.00%	-3.80%	-2.40%	-1.60%	-0.40%
	3.38in / 86mm	-31.20%	-14.00%	-5.60%	-3.40%	-2.00%	-1.20%	0.00%
	3.47in / 88mm	-31.10%	-13.60%	-5.00%	-2.70%	-1.30%	-0.50%	0.80%
	3.53in / 90mm	-31.40%	-13.40%	-4.60%	-2.30%	-0.90%	0.00%	1.30%
	3.594in / 91mm	-31.70%	-13.20%	-4.10%	-1.70%	-0.30%	0.60%	1.90%

Table 6. LMA3 projected relative changes to Number of lobsters Landed resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	-11.10%	-0.80%	3.20%	4.00%	4.50%	4.70%	5.00%
	3.31in / 84mm	-12.20%	-1.70%	2.30%	3.20%	3.70%	3.90%	4.20%
	3.38in / 86mm	-13.20%	-2.60%	1.50%	2.30%	2.80%	3.10%	3.40%
	3.47in / 88mm	-15.20%	-4.20%	-0.10%	0.80%	1.30%	1.50%	1.80%
	3.53in / 90mm	-17.10%	-5.90%	-1.70%	-0.80%	-0.30%	0.00%	0.30%
	3.594in / 91mm	-19.50%	-7.90%	-3.60%	-2.60%	-2.10%	-1.90%	-1.50%

Table 7. LMA3 projected relative changes to Spawning Stock Biomass resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	56.00%	19.00%	3.00%	-1.50%	-3.80%	-5.20%	-6.90%
	3.31in / 84mm	57.00%	20.00%	3.00%	-0.80%	-3.10%	-4.50%	-6.20%
	3.38in / 86mm	59.00%	21.00%	4.00%	0.00%	-2.40%	-3.70%	-5.50%
	3.47in / 88mm	61.00%	23.00%	6.00%	1.50%	-0.90%	-2.30%	-4.10%
	3.53in / 90mm	64.00%	25.00%	8.00%	3.80%	1.40%	0.00%	-1.80%
	3.594in / 91mm	69.00%	29.00%	11.00%	6.70%	4.20%	2.80%	1.00%

Table 8. LMA3 projected relative changes to Exploitation resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell).

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	-20.40%	-0.30%	8.40%	10.30%	11.40%	11.90%	12.50%
	3.31in / 84mm	-22.30%	-2.40%	6.30%	8.10%	9.20%	9.70%	10.30%
	3.38in / 86mm	-24.10%	-4.40%	4.10%	6.00%	7.00%	7.50%	8.10%
	3.47in / 88mm	-27.40%	-8.10%	0.30%	2.20%	3.10%	3.70%	4.30%
	3.53in / 90mm	-30.60%	-11.60%	-3.30%	-1.50%	-0.50%	0.00%	0.60%
	3.594in / 91mm	-34.20%	-15.60%	-7.50%	-5.70%	-4.80%	-4.20%	-3.70%

Table 9. OCC projected relative changes to Weight of Landings resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell), based on (A) LMA1 or (B) LMA3 parameterizations.

A.

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	-5.60%	-5.00%	-4.90%	-4.90%	-4.90%	-4.90%	-4.90%
	3.31in / 84mm	-2.70%	-2.00%	-1.90%	-1.90%	-1.90%	-1.90%	-1.90%
	3.38in / 86mm	-0.90%	-0.10%	0.00%	0.00%	0.00%	0.00%	0.00%
	3.47in / 88mm	6.60%	7.80%	8.00%	8.00%	8.00%	8.00%	8.00%
	3.53in / 90mm	7.40%	8.80%	8.90%	8.90%	8.90%	8.90%	8.90%
	3.594in / 91mm	9.30%	11.00%	11.20%	11.20%	11.20%	11.20%	11.20%

B.

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	-30.40%	-13.50%	-5.20%	-3.00%	-1.60%	-0.80%	0.00%
	3.31in / 84mm	-30.30%	-13.20%	-4.80%	-2.60%	-1.20%	-0.40%	1.00%
	3.38in / 86mm	-30.30%	-13.00%	-4.40%	-2.20%	-0.80%	0.00%	1.00%
	3.47in / 88mm	-30.30%	-12.50%	-3.80%	-1.50%	-0.10%	0.70%	2.00%
	3.53in / 90mm	-30.60%	-12.40%	-3.40%	-1.10%	0.40%	1.20%	3.00%
	3.594in / 91mm	-30.90%	-12.10%	-2.90%	-0.50%	1.00%	1.90%	3.00%

Table 10. OCC projected relative changes to Number of lobsters Landed resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell), based on (A) LMA1 or (B) LMA3 parameterizations.

A.

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	3.40%	3.60%	3.60%	3.60%	3.60%	3.60%	3.60%
	3.31in / 84mm	1.30%	1.60%	1.60%	1.60%	1.60%	1.60%	1.60%
	3.38in / 86mm	-0.30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	3.47in / 88mm	-5.40%	-4.90%	-4.90%	-4.90%	-4.90%	-4.90%	-4.90%
	3.53in / 90mm	-6.40%	-5.90%	-5.90%	-5.90%	-5.90%	-5.90%	-5.90%
	3.594in / 91mm	-8.30%	-7.70%	-7.70%	-7.70%	-7.70%	-7.70%	-7.70%

B.

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	-13.80%	-3.70%	0.10%	0.90%	1.40%	1.60%	1.90%
	3.31in / 84mm	-14.80%	-4.60%	-0.70%	0.10%	0.60%	0.80%	1.10%
	3.38in / 86mm	-15.80%	-5.50%	-1.50%	-0.70%	-0.20%	0.00%	0.30%
	3.47in / 88mm	-17.70%	-7.10%	-3.10%	-2.20%	-1.70%	-1.50%	-1.20%
	3.53in / 90mm	-19.60%	-8.70%	-4.60%	-3.70%	-3.20%	-3.00%	-2.70%
	3.594in / 91mm	-21.90%	-10.70%	-6.40%	-5.50%	-5.00%	-4.80%	-4.50%

Table 11. OCC projected relative changes to Spawning Stock Biomass resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell), based on (A) LMA1 or (B) LMA3 parameterizations.

A.

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	-9.80%	-24.70%	-26.40%	-26.50%	-26.60%	-26.60%	-26.60%
	3.31in / 84mm	7.00%	-11.10%	-13.10%	-13.30%	-13.30%	-13.30%	-13.30%
	3.38in / 86mm	24.30%	2.70%	0.30%	0.10%	0.00%	0.00%	0.00%
	3.47in / 88mm	78.20%	45.10%	41.50%	41.20%	41.10%	41.00%	41.00%
	3.53in / 90mm	95.50%	58.50%	54.40%	54.00%	53.90%	53.90%	53.90%
	3.594in / 91mm	126.20%	81.80%	77.00%	76.60%	76.50%	76.40%	76.40%

B.

		Maximum Gauge Size						
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	None
Minimum Gauge Size	3.25in / 83mm	63.00%	24.00%	7.00%	2.00%	-0.10%	-1.50%	-3.30%
	3.31in / 84mm	64.00%	25.00%	7.00%	3.00%	0.60%	-0.70%	-2.60%
	3.38in / 86mm	65.00%	26.00%	8.00%	4.00%	1.40%	0.00%	-1.80%
	3.47in / 88mm	67.00%	27.00%	10.00%	5.00%	2.90%	1.50%	-0.30%
	3.53in / 90mm	71.00%	30.00%	12.00%	8.00%	5.30%	3.90%	2.00%
	3.594in / 91mm	75.00%	34.00%	15.00%	11.00%	8.30%	6.80%	4.90%

Table 12. OCC projected relative changes to Exploitation resulting from alternative minimum and maximum options, relative to the current regulations (yellow cell), based on (A) LMA1 or (B) LMA3 parameterizations.

A.

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	15.60%	16.50%	16.50%	16.50%	16.50%	16.50%	16.50%
	3.31in / 84mm	5.80%	6.70%	6.80%	6.80%	6.80%	6.80%	6.80%
	3.38in / 86mm	-1.10%	-0.10%	0.00%	0.00%	0.00%	0.00%	0.00%
	3.47in / 88mm	-18.40%	-17.30%	-17.10%	-17.10%	-17.10%	-17.10%	-17.10%
	3.53in / 90mm	-21.50%	-20.20%	-20.10%	-20.10%	-20.10%	-20.10%	-20.10%
	3.594in / 91mm	-26.70%	-25.30%	-25.20%	-25.20%	-25.20%	-25.20%	-25.20%

B.

		Maximum Gauge Size						None
		5in / 127mm	5.5in / 140mm	6in / 152mm	6.25in / 159mm	6.5in / 165mm	6.75in / 171mm	
Minimum Gauge Size	3.25in / 83mm	-26.00%	-7.30%	0.80%	2.60%	3.60%	4.10%	4.60%
	3.31in / 84mm	-27.70%	-9.20%	-1.20%	0.60%	1.50%	2.00%	2.60%
	3.38in / 86mm	-29.40%	-11.10%	-3.20%	-1.40%	-0.50%	0.00%	0.60%
	3.47in / 88mm	-32.50%	-14.50%	-6.70%	-5.00%	-4.10%	-3.60%	-3.00%
	3.53in / 90mm	-35.40%	-17.70%	-10.00%	-8.40%	-7.50%	-7.00%	-6.50%
	3.594in / 91mm	-38.80%	-21.50%	-13.90%	-12.30%	-11.40%	-10.90%	-10.40%